DRAFT ENVIRONMENTAL IMPACT STATEMENT ON

COLSTRIP ELECTRIC GENERATING UNITS 3 & 4, 500 KILOVOLT TRANSMISSION LINES & ASSOCIATED FACILITIES

VOLUME THREE-B POWER PLANT-APPENDIXES

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

ENERGY PLANNING DIVISION, MONTANA STATE DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

HELENA, MONTANA 59601

NOVEMBER, 1974

DRAFT ENVIRONMENTAL IMPACT STATEMENT ON

THE PROPOSED MONTANA POWER COMPANY, PUGET SOUND POWER & LIGHT COMPANY, PORTLAND GENERAL ELECTRIC COMPANY, PACIFIC POWER AND LIGHT COMPANY, AND WASHINGTON WATER POWER COMPANY, COLSTRIP ELECTRIC GENERATING UNITS 3 & 4, 500 KILOVOLT KV TRANSMISSION LINES FROM COLSTRIP TO HOT SPRINGS, MONTANA, AND ASSOCIATED FACILITIES

ENERGY PLANNING DIVISION
ALBERT C. TSAO, ADMINISTRATOR
DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
GARY J. WICKS, DIRECTOR

NOVEMBER, 1974

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VOLUME 3B

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APPENDIX A: Meteorology and Air Quality

A1 Historical Air Quality Data

The following tables present various air monitoring data collected since 1971 in the Colstrip area. Table 1 summarizes the total suspended particles for 1972 and 1973. Although the highest concentrations were recorded at Miles City, these data are affected greatly by local traffic and are not representative of the majority of southeastern Montana. Excluding the Miles City station, greatest concentrations were recorded at the Ira Greson station in Rosebud County. The accompanying Historical Air Monitoring Sites map shows the relative location of the sampling sites. A key to the map is given in Table 2.

Table 3 summarizes data for dustfall collected in dustfall buckets. Values are in tons per square mile. The most dustfall was recorded in the Broadus area in 1972 and in the Miles City area in 1973.

Sulfation rates are given in Table 4 for 1971-1973. Values as high as 0.80 mg SO_3/100 cm^2/day were recorded at one site. The average values were approximately 0.05 mg at most stations.

Fluorides in the air were measured by both Sodium Formate plates and Calcium Formate papers and are summarized in Tables 5 and 6. Values are in micrograms of fluoride per square centimeter per 30 days. Most readings were very low; the average was around 0.01 or 0.02 µg. In only one case did a value exceed 0.50 g and that was 2.23 g on the Decker to Birney road.

Although various pollutants were measured in the area prior to 1974, more sophisticated measurements were needed to determine background levels of other pollutants such as ozone, carbon monoxide, and oxides of nitrogen. Data for these and other pollutants is discussed in Section 10.1.2. in the text.

TABLE 1
TOTAL SUSPENDED PARTICULATE DATA MILES CITY AQCR
Jan. 1972 - Dec. 1972
(in micrograms per cubic meter)

Station	Minimum	Frequency Distribution (% of values equal to or less than stated one) 10%	30%	50%	70%	90%	95%	98%	Maximum	Arith. Mean	Arith. Std. Dev.	Geo. Mean	Geo. Std. Dev.	Total No. Obs.
Assay Res. Custer Co. 1040001	8	14	28	54	104	237	288	394	405	90	93	55	3	111
LaFlamme Powder River 1240006	8	18	25	36	51	82	105	105	150	47	32	39	2	26
Kluver Ranch Rosebud Co. 1360009	3	6	10	14	23	52	53	87	111	24	24	17	2	36
Ira Gresons Rosebud Co. 1360021	7	13	44	67	114	190	191	257	284	92	71	63	3	35
Bailey Ranch Rosebud Co. 1360024	2	2	4	5	3	10	10	10	10	6	3	6	1	10
Hardin MDU Big Horn Co. 0680001	24	28	44	59	69	116	135	145	147	67	34	59	1	37
Carlot Ranch Big Horn Co. 0060008	3	3	4	8	9	10	25	25	25	9	7	8	2	7

TABLE 1 (cont.)
TOTAL SUSPENDED PARTICULATE DATA MILES CITY AQCR
Jan. 1972 - Dec. 1972
(in micrograms per cubic meter)

Number of
Samples Reported Per Month

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Assay Res. Custer Co. 1040001	8	10	10	9	10	10	9	3	10	11	11	10
LaFlamme Powder River 1240006	0	0	0	1	3	4	0	3	5	4	4	2
Kluver Ranch Rosebud Co. 1360009	0	0	0	5	5	4	5	4	1	3	4	5
Ira Gresons Rosebud Co. 1360021	0	0	0	4	5	4	5	5	5	1	2	4
Bailey Ranch Rosebud Co. 1360024	0	0	0	0	0	0	0	0	0	1	4	5
Hardin MDU Big Horn Co. 0680001	0	0	0	3	4	5	4	4	4	4	5	4
Carlot Ranch Big Horn Co. 0060008	0	0	0	0	0	0	0	0	0	1	3	3

TABLE 1 (cont.)
TOTAL SUSPENDED PARTICULATE DATA MILES CITY AQCR
Jan. 1973 - Dec. 1973
(in micrograms per cubic meter)

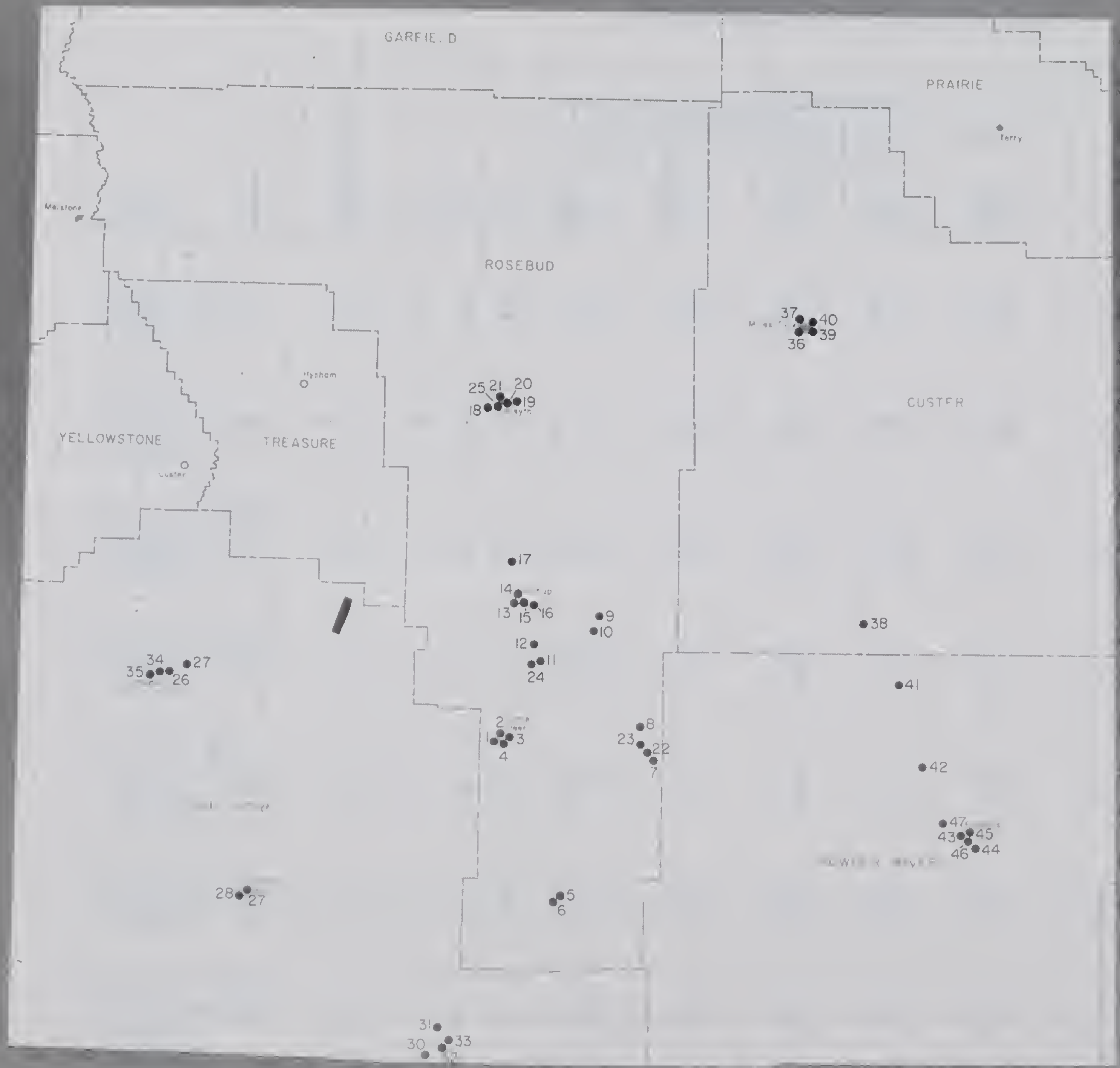
Station	Minimum	Frequency Distribution (% of values equal to or less than stated one) 10%	30%	50%	70%	90%	95%	98%	Maximum	Arith. Mean	Arith.-Std. Dev.	Geo. Mean	Geo. Std. Dev.	Total No. Obs.
Assay Res. Custer Co. 1040001	7	16	52	89	184	325	361	394	694	139	131	85	3	81
LaFlamme Powder River 1240006	2	2	8	15	20	33	44	55	55	18	15	12	3	17
Kluver Ranch Rosebud Co. 1360009	3	5	10	23	35	69	84	123	138	32	31	21	3	43
Bailey Ranch Rosebud Co. 1360024	1	4	9	16	21	33	49	64	73	19	15	14	2	45
Ferris Res. Rosebud Co. 1360025	14	14	16	20	36	146	157	180	180	57	59	36	2	15
Hardin MDU Big Horn Co. 0680001	21	31	87	132	160	229	246	255	257	132	68	111	2	41
Carlot Ranch Big Horn Co. 0060008	2	4	8	16	22	31	34	35	44	17	11	13	2	46

TABLE 1 (cont.)
TOTAL SUSPENDED PARTICULATE DATA MILES CITY AQCR
Jan. 1973 - Dec. 1973
(in micrograms per cubic meter)

Number of Samples Reported Per Month

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Assay Res. Custer Co. 1040001	9	9	11	9	3	6	7	10	5	6	4	2
LaFalmme Powder River 1240006	4	4	5	4	0	0	0	0	0	0	0	0
Kluver Ranch Rosebud Co. 1360009	5	4	5	5	6	5	1	3	5	4	0	0
Bailey Ranch Rosebud Co. 1360024	5	4	5	5	5	4	5	5	4	3	0	0
Ferris Res. Rosebud Co. 1360025	5	4	2	1	1	2	0	0	0	0	0	0
Hardin MDU Big Horn Co. 0680001	3	4	5	4	4	5	4	5	4	3	0	0
Carlot Ranch Big Horn Co. 0060008	6	4	5	4	4	4	3	5	3	4	3	1

HISTORICAL AIR MONITORING SITES



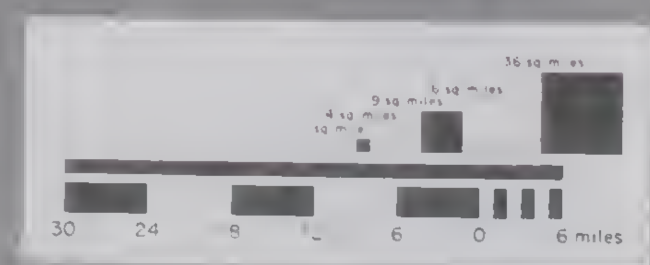


TABLE 2

No.	Station	County	I.D. No.	Samplers*
1	Lame Deer West	Rosebud	1360001	SN
2	Lame Deer N	"	1360002	SN
3	Lame Deer E	"	1360003	DSNCV
4	Lame Deer LDS Ch.	"	1360004	SN
5	Birney NE	"	1360005	DSNV
6	Birney SW	"	1360006	SN
7	Ashland E	"	1360007	SN
8	Ashland N	"	1360008	SN
9	Kluver Ranch	"	1360009	SNCH
10	Junction Station	"	1360010	DSNV
11	Colstrip S	"	1360011	SNV
12	Peabody E	"	1360012	DSNV
13	West Ener. Off.	"	1360013	SN
14	Water Tower	"	1360014	DSNCV
15	Warehouse	"	1360015	SN
16	Gun Club Station	"	1360016	SC
17	Oil Storage Tank	"	1360017	SN
18	Forsyth W	"	1360018	DSNV
19	Forsyth E	"	1360019	DSNV
20	Forsyth Depot	"	1360020	SN
21	Ira Gresons	"	1360021	SCH
22	Ashland Power	"	1360022	DSNV
23	St. Labre Miss.	"	1360023	S
24	Bailey Ranch	"	1360024	H
25	Ferris Res.	"	1360025	H
26	Hardin East	Big Horn	0060001	SN

TABLE 2
(cont.)

No.	Station	County	I.D. No.	Samplers*
27	Radio Tower	Big Horn	0060002	DSNV
28	Lodge Grass W	"	0060003	SN
29	Lodge Grass E	"	0060004	DSNV
30	Decker Post Office	"	0060005	DSNV
31	Decker to Birney	"	0060006	SN
32	Decker Coal at Br.	"	0060007	DSNV
33	Carlot Ranch	"	0060008	DSNV
34	Hardin MDU	"	0680001	SC
35	Hardin West	"	0680002	SN
36	F & G Off.	Custer	0300001	DSNV
37	Gravel Pit N	"	0300002	SN
38	Volburg	"	0300003	DSNV
39	Asay's Res.	"	1040001	DSNVH
40	Miles City E	"	1040002	DSCV
41	Coalwood	Powder River	1240001	SN
42	Ash Creek	"	1240002	S
43	W. Broadus	"	1240003	DSNV
44	Broadus E	"	1240004	DSNV
45	Sewage Lagoon	"	1240005	SN
46	LaFlamme	"	1240006	SCH
47	312-212 Jct.	"	1240007	S

*S - sulfation rate
N - Na Formate Plate (F^-)
C - Ca Formate paper (F^-)
D - Dustfall

V - Vegetation (F^-)
H - Hi-vol (Total suspended particulate)

TABLE 3
Background Dustfall Measurements Taken in
Southeastern Montana by SDHES
(Values in Tons/mile^2)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud	Lame Deer E 1360003	9.0	16.0	9	7.6	11.8	4
	Birney NE 1360005	9.2	11.6	8	10.6	17.9	4
	Junction Sta. 1360010	18.8	49.6	6	19.3	34.6	7
	Peabody E. 1360012	7.2	17.2	9	12.0	34.0	4
	Water Tower 1360014	9.1	29.8	9	5.7	10.3	7
	Forsyth W 1360018	14.4	30.0	9	10.6	17.0	4
	Forsyth E 1360019	16.7	25.5	9	15.9	24.7	4
	Ashland Pwr Substa 1360022	7.7	18.4	8	7.8	10.2	4
Big Horn	Radio Tower 0060002	5.4	14.2	6	4.9	18.1	7
	Lodge Grass E 0060004	17.4	28.5	6	15.2	23.9	4

TABLE 3 (cont.)
Background Dustfall Measurements Taken in
Southeastern Montana by SDHES
(Values in Tons/mile^2)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Big Horn	Decker Post Off. 0060005	8.1	22.7	6	6.4	21.2	6
	Decker Coal @ Br. 0060007	16.7	39.0	7	24.6	58.1	5
	Carlot Ranch 0060008	-	-	-	10.2	13.1	3
Custer	F & G Off. 0300001	13.6	37.6	9	8.8	13.6	4
	Volburg 0300003	5.0	10.0	9	3.4	7.1	4
	Assay Res. 1040001	22.1	37.8	6	36.9	61.2	4
	Miles City E 1040002	22.5	35.8	9	22.0	33.6	4
Powder River	W Broadus 1240003	33.4	75.5	8	18.9	25.7	4
	Broadus E 1240004	23.5	124.0	9	8.4	15.4	4

TABLE 4
Background Sulfation Rates Measured in Southeastern Montana by SDHES
(Values in mg SO_3/100 cm^2/day)

County	Station	1971 Aver.	1971 Max.	1971 Samples	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud	Lame Deer W 1360001	-	-	-	0.06	0.13	9	0.04	0.11	4
	Lame Deer N 1360002	-	-	-	0.06	0.13	9	0.07	0.21	5
	Lame Deer E 1360003	-	-	-	0.03	0.10	6	0.02	0.08	4
	Lame Deer LDS Ch 1360004	-	-	-	0.04	0.13	6	0.05	0.21	5
	Birney NE 1360005	-	-	-	0.04	0.16	8	0.01	0.05	5
	Birney SW 1360006	-	-	-	0.05	0.13	7	0.01	0.05	5
	Ashland E 1360007	-	-	-	0.05	0.10	9	0.03	0.08	3
	Ashland N 1360008	-	-	-	0.08	0.16	8	0.10	0.24	5
	Kluver Ranch 1360009	-	-	-	0.04	0.13	9	0.01	0.06	10
	Junction Sta. 1360010	-	-	-	0.04	0.18	8	0.01	0.06	10
	Colstrip S 1360011	0.02	0.02	3	0.03	0.12	12	0.02	0.06	10
	Peabody E 1360012	-	-	-	0.04	0.07	8	0.01	0.06	10

TABLE 4 (cont.)
Background Sulfation Rates Measured in Southeastern Montana by SDHES
(Values in mg SO_3/100 cm^2/day)

County	Station	1971 Aver.	1971 Max.	1971 Samples	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud (cont.)	West. Ener Off 1360013	0.16	0.16	3	0.14	0.27	11	0.09	0.26	10
	Water Tower 1360014	0.16	0.16	3	0.12	0.23	10	0.04	0.16	10
	Warehouse Substa 1360015	0.04	0.04	3	0.06	0.16	10	0.02	0.09	10
	Gun Club Sta. 1360016	-	-	-	0.04	0.10	11	0.04	0.10	7
	Oil Stor. Tank 1360017	0.05	0.05	3	0.06	0.13	8	0.02	0.10	10
	Forsyth W 1360018	-	-	-	0.10	0.24	9	0.03	0.08	5
	Forsyth E 1360019	-	-	-	0.06	0.15	9	0.03	0.09	5
	Forsyth Depot 1360020	-	-	-	0.08	0.14	8	0.06	0.15	5
	Ira Gresons 1360021	-	-	-	0.05	0.17	9	0.02	0.04	5
	Ashland Pwr Substa. 1360022	-	-	-	0.06	0.14	8	0.04	0.13	5
	St. Labre Miss. 1360023	-	-	-	0.04	0.14	8	0.03	0.14	5

TABLE 4 (cont.)
Background Sulfation Rates Measured in Southeastern Montana by SDHES
(Values in mg SO_3/100 cm^2/day)

County	Station	1971 Aver.	1971 Max.	1971 Samples	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Big Horn	Hardin East 0060001	-	-	-	0.08	0.23	8	0.03	0.11	9
	Radio Tower 0060002	-	-	-	0.08	0.19	8	0.02	0.12	10
	Lodge Grass W 0060003	-	-	-	0.04	0.08	7	0.05	0.09	4
	Lodge Grass E 0060004	-	-	-	0.05	0.13	8	0.08	0.27	5
	Decker Post Off. 0060005	-	-	-	0.06	0.14	8	0.01	0.08	12
	Decker to Birney Road 0060006	-	-	-	0.03	0.08	7	0.01	0.07	12
	Decker Coal @ Br 0060007	-	-	-	0.04	0.15	8	0.01	0.08	12
	Carlot Ranch 0060008	-	-	-	-	-	-	0.00	0.01	11
	Hardin MDU 0680001	-	-	-	0.07	0.28	8	0.02	0.06	10
	Hardin West 0680002	-	-	-	0.08	0.24	8	0.03	0.08	9
Custer	F & G Off. 0300001	-	-	-	0.06	0.17	8	0.03	0.09	5

TABLE 4 (cont.)
Background Sulfation Rates Measured in Southeastern Montana by SDHES
(Values in mg SO_3/100 cm^2/day)

County	Station	1971 Aver.	1971 Max.	1971 Samples	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Custer	Gravel Pit N 0300002	-	-	-	0.06	0.16	8	0.04	0.07	5
	Volburg 0300003	-	-	-	0.04	0.14	9	0.02	0.06	5
	Assay Res. 1040001	-	-	-	0.06	0.15	9	0.04	0.11	5
	Miles City E 1040002	-	-	-	0.08	0.21	9	0.04	0.08	5
Powder River	Coalwood 1240001	-	-	-	0.05	0.15	9	0.03	0.10	4
	Ash Creek 1240002	-	-	-	0.05	0.14	9	0.02	0.05	4
	W Broadus 1240003	-	-	-	0.07	0.21	7	0.03	0.13	5
	Broadus E. 1240004	-	-	-	0.06	0.16	8	0.03	0.10	5
	Sewage Lagoon 1240005	-	-	-	0.14	0.38	8	0.22	0.80	5
	LaFlamme 1240006	-	-	-	0.05	0.21	7	0.03	0.09	5
	312-212 Junc 1240007	-	-	-	0.04	0.15	9	0.02	0.05	5

TABLE 5
Background Fluoride Levels Measured in Southeastern Montana by SDHES
(Values in ug $F^-/cm^2/30$ days)
(Sodium Formate Plates)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud	Lame Deer W 1360001	0.00	0.00	7	0.02	0.12	5
	Lame Deer N 1360002	0.01	0.10	8	0.00	0.00	5
	Lame Deer E 1360003	0.00	0.00	6	0.00	0.00	5
	Lame Deer LDS Ch. 1360004	-	-	-	0.00	0.00	1
	Birney NE 1360005	0.00	0.00	8	0.03	0.14	5
	Birney SW 1360006	0.00	0.00	8	0.00	0.00	5
	Ashland E 1360007	0.02	0.22	9	0.03	0.14	5
	Ashland N 1360008	0.00	0.00	7	0.02	0.10	5
	Kluver Ranch 1360009	0.02	0.18	8	0.00	0.00	10
	Junction Sta. 1360010	0.00	0.00	8	0.00	0.00	10

TABLE 5 (cont.)
Background Fluoride Levels Measured in
Southeastern Montana by SDHES
(Values in ug $F^-/cm^2/30$ days)
(Sodium Formate Plates)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud	Colstrip S 1360011	0.03	0.15	11	0.01	0.10	10
	Peabody E 1360012	0.00	0.00	8	0.00	0.00	9
	West. Ener. Off. 1360013	0.04	0.22	11	0.00	0.00	10
	Water Tower 1360014	0.05	0.19	10	0.00	0.00	9
	Warehouse Substa. 1360015	0.03	0.17	11	0.00	0.00	10
	Oil Storage Tank 1360017	0.05	0.19	8	0.00	0.00	9
	Forsyth W 1360018	0.00	0.00	8	0.00	0.00	5
	Forsyth E 1360019	0.00	0.00	7	0.00	0.00	5
	Forsyth Depot. 1360020	0.00	0.00	6	0.00	0.00	5

TABLE 5 (cont.)
Background Fluoride Levels Measured in
Southeastern Montana by SDHES
(Values in ug $F^-/cm^2/30$ days)
(Sodium Formate Plates)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud	Ashland Pwr Substa 1360022	0.01	0.10	7	0.00	0.00	5
Big Horn	Hardin E 0060001	-	-	-	0.00	0.00	1
	Radio Tower 0060002	0.02	0.15	8	0.00	0.00	10
	Lodge Grass W 0060003	0.05	0.20	7	0.00	0.00	4
	Lodge Grass E 0060004	0.02	0.20	8	0.03	0.15	5
	Decker Post Off. 0060005	0.00	0.00	7	0.00	0.00	12
	Decker to Birney Rd. 0060006	0.32	2.24	7	0.00	0.00	11
	Decker Coal @ Br. 0060007	0.02	0.16	8	0.00	0.00	11
	Carlot Ranch 0060008	-	-	-	0.00	0.00	11

TABLE 5 (cont.)
Background Fluoride Levels Measured in
Southeastern Montana by SDHES
(Values in ug $F^-/cm^2/30$ days)
(Sodium Formate Plates)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Big Horn	Hardin W 0680002	0.04	0.18	8	0.00	0.00	10
Custer	F & G Office 0300001	0.01	0.10	8	0.00	0.00	5
	Gravel Pit N 0300002	0.00	0.00	7	0.00	0.00	5
	Volburg 0300003	0.00	0.00	8	0.00	0.00	4
	Assay Res. 1040001	0.00	0.00	8	0.00	0.00	5
Powder River	Coalwood 1240001	0.07	0.50	7	0.00	0.00	5
	W Broadus 1240003	0.00	0.00	7	0.02	0.10	5
	Broadus E 1240004	0.02	0.15	8	0.00	0.00	5
	Sewage Lagoon 1240005	0.00	0.00	6	0.00	0.00	5

TABLE 6

Background Fluoride Levels Measured in
Southeastern Montana by SDHES
(Values in ug $F^-/cm^2/30$ days
(Calcium Formate Papers)

County	Station	1972 Aver.	1972 Max.	1972 Samples	1973 Aver.	1973 Max.	1973 Samples
Rosebud	Lame Deer E 1360003	0.02	0.07	9	0.01	0.01	4
	Kluver Ranch 1360009	0.01	0.04	9	0.01	0.03	10
	Water Tower 1360014	0.07	0.23	9	0.02	0.05	10
	Gun Club Sta. 1360016	0.04	0.06	9	0.04	0.15	10
	Ira Gresons 1360021	0.03	0.08	9	0.02	0.04	5
Big Horn	Hardin MDU 0680001	0.03	0.06	8	0.04	0.11	9
Custer	Miles City E 1040002	0.02	0.03	8	0.03	0.04	5
Powder River	LaFlamme 1240006	0.01	0.02	7	0.01	0.03	5

A2 Methods and Procedures of Sample Collection

High-Volume Sampler

This sampling device is used to sample suspended atmospheric particulate pollutants. Specific particle size fractions sampled cannot be defined; however, this type unit, housed in a shelter, will sample under quiescent conditions particles to 100 microns in diameter having a specific gravity of 2.65 and average velocity of 64 feet per minute across the horizontal air inlet portal of the shelter. Wind will upset this relationship and allow collections of larger and heavier solids.

A typical "hi-vol" is shown in Figure 1. A vacuum sweeper motor pulls air through a glass fiber filter which offers high filtering efficiency for submicron particles with minimum pressure drop throughout the sampling period and with limited water absorption from the air.

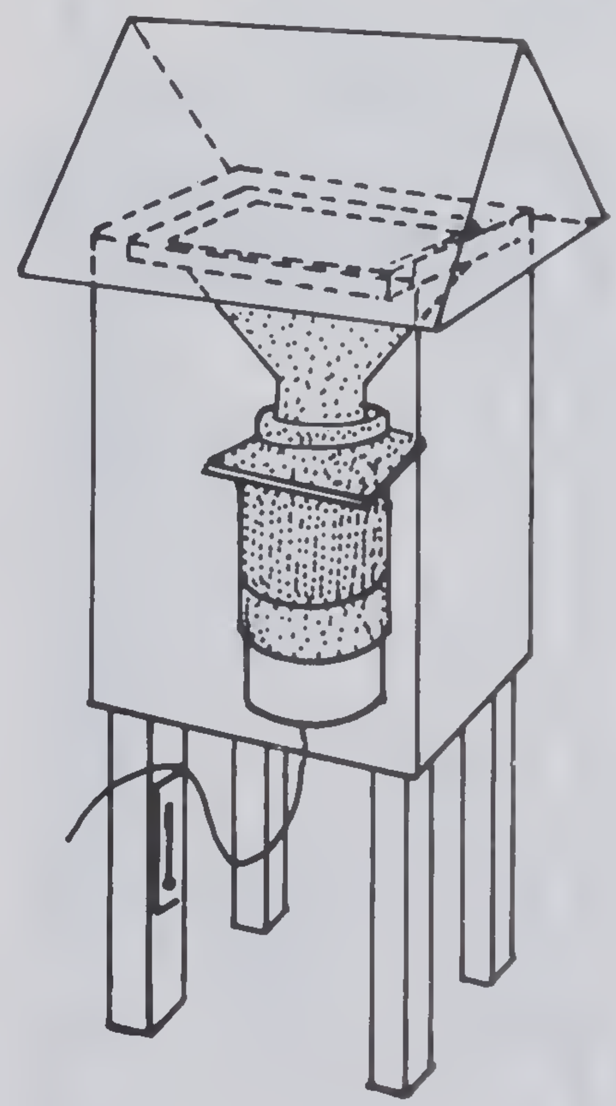
Prior to use, each filter is seralized and weighted or an analytical balance under laboratory conditions. The filter is shipped to the sampling site where ambient air is drawn through it for 24 hours. A calibrated field-type rotameter reading is made before and after the 24-hour sample is taken. The average of these two cubic foot per minute rates is used to find the total volume of air which has passed through the sampler. The filter is returned to Helena where it is equilibrated at laboratory conditions before a second precision weighing is made. This difference in weight along with the total volume of air drawn through the device in 24 hours gives the total suspended particulate loading in micrograms per cubic meter of ambient air.

The primary advantage of the hi-vol is that it will sample a large volume of air in a relatively short period of time. Disadvantages include substantial original costs followed by fairly high filter, operating, and analysis costs. Electrical current also must be obtained, which limits sampler location.

High-Volume Particle Fractionating Cascade

Impactor

The high-volume particle fractionating cascade impactor, manufactured



HIGH-VOLUME PARTICULATE SAMPLER

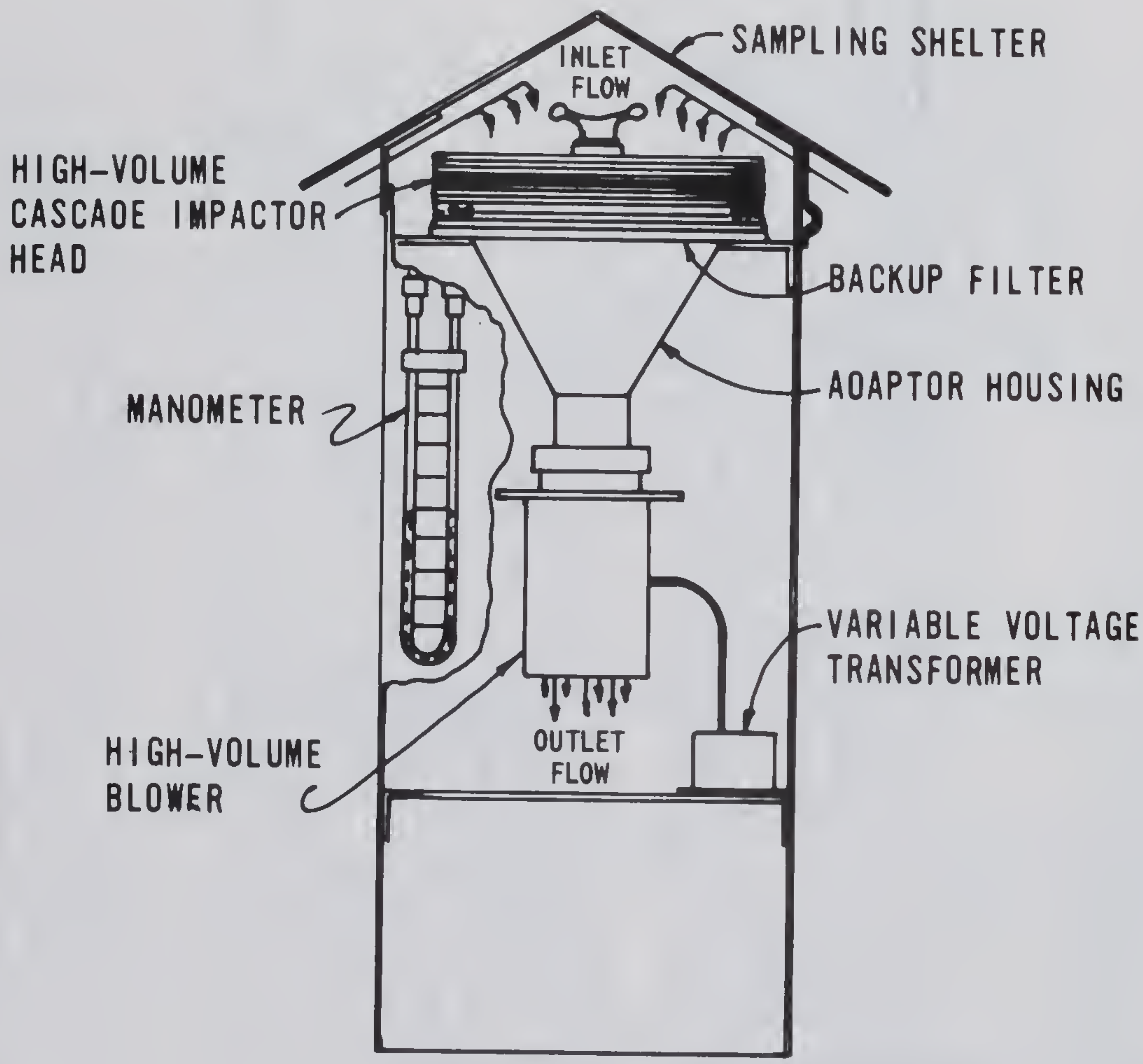
FIGURE 1

by Anderson 2000 Inc., is a multistage, multijet unit consisting of five aluminum jet plates separated by sized neoprene rubber gaskets (Figure 3). The plates, which are approximately 12 inches in diameter and contain approximately 300 sized jets, are backed by a standard 8 by 10 inch hi-vol filter to collect submicron particles. The alignment of the 12-inch plates and resulting air flow patterns direct the particles onto the surface of the jet plates below. The collection surface is covered with a cut and perforated fiberglass filter which has been preconditioned and weighed. The size and location of the jets are held to very close quality-control tolerances to give proper fractionation, and collection medium contains punched holes so that it does not obstruct the jet openings in the plates. The head interface plate contains four dowl pins and a center post for properly locating the jet plates with respect to each other and for aligning the collection medium with the jet plates. The assembled head is positioned on a 9 by 11 inch interface gasket and attached to a conventional hi-vol filter holder inside the hi-vol shelter (Figure 2) with a standard hi-vol air mover used to induce air flow through the system. The aerodynamic separation of the five plates allows the collections of: 7.0 microns (μ) and above, 3.3--7.0 μ, 2.0-3.3 μ, 1.1-2.0 μ, and 0.1-1.1 μ. Regulation of the air flow through the fractionator is achieved by adjusting a variable voltage transformer and noting the corresponding pressure drop through the assembled fractionator as indicated by a manometer. For proper fractionation and sizing, the fractionator should operate at 20 ft^3/min. Since the fractionator collects the major portion of samples, and especially the large particles, the flow rate will remain constant except for minor line voltage fluctuations.

Membrane Sampler

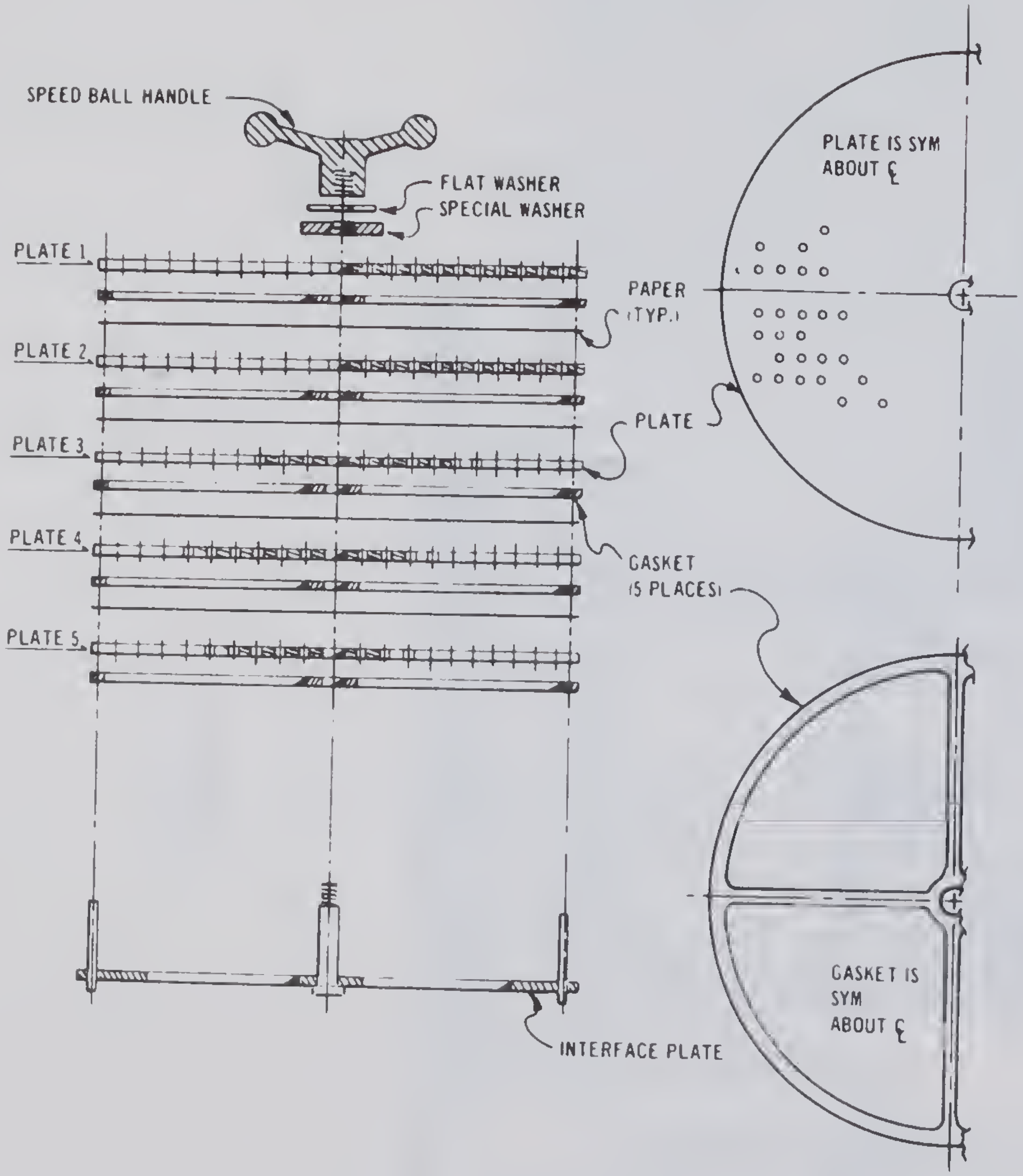
The membrane sampler collects total suspended particulate matter as do the "hi-vol" and impactor samplers. Since the air flow through the filter is approximately 3 to 4.5 cubic feet per minute, the shelter inlet air flow differs from that of the "hi-vol" and impactor in that the lower flow rate aerodynamically draws in lighter particles.

A large puller motor is needed to overcome the increased flow resistance of the cellulose membrane filter material, which is 10 cm in diameter.



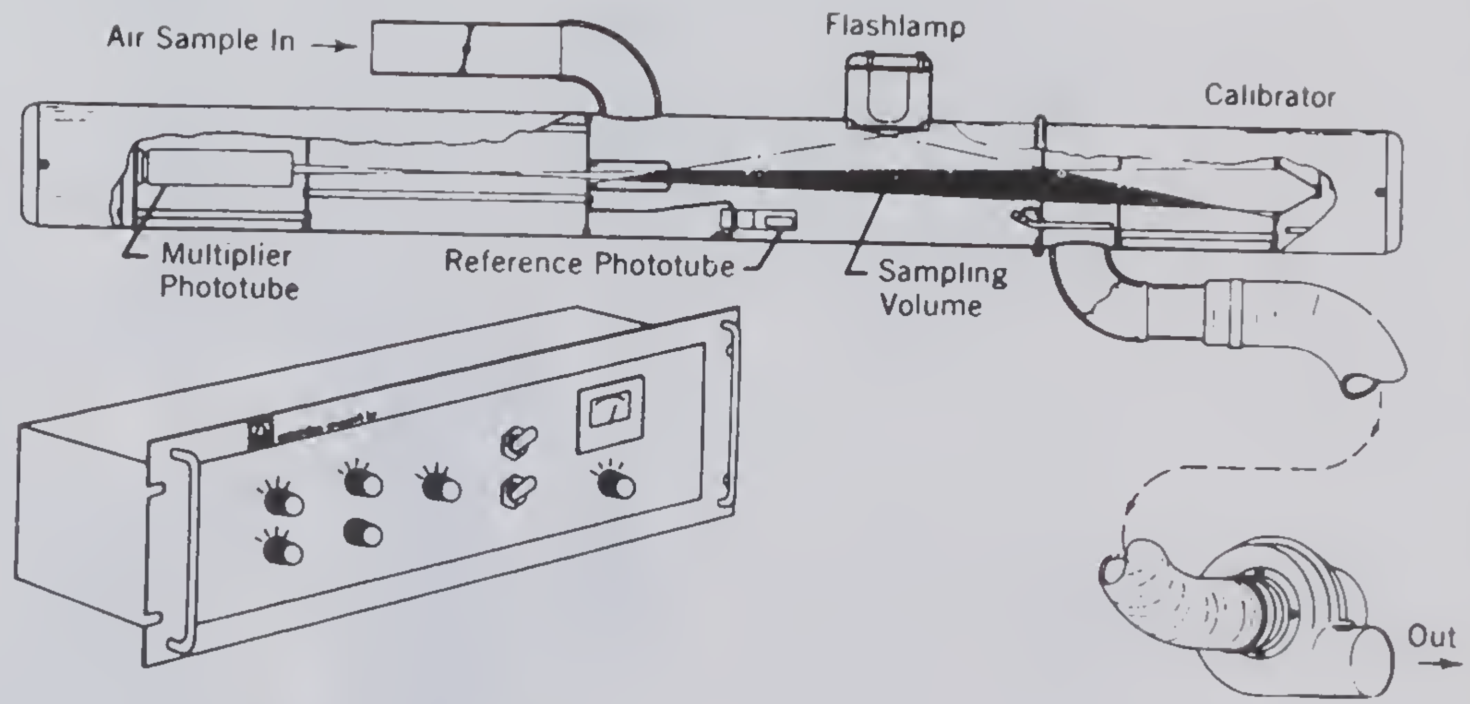
HIGH-VOLUME CASCAOE IMPACTOR WITH
BACKUP FILTER FOR SAMPLING ATMOSPHERIC AEROSOLS

FIGURE 2



High Volume Fractionating Sampling Head

Figure 3



Mechanical Assemblies of MIR Integrating Nephelometer

Figure 4

ınis sampler is used because the membrane filters do not in general contain the trace metal contamination associated with the fiberglass filters. The total membrane filter can be digested in acid during the sample preparation allowing for better chemical detection of trace elements than fiberglass filters.

There are some flow problems associated with these filters, however, since cellulose tends to collect and retain moisture.

<u>The Dustfall Jar</u>

The dustfall jar may be any of a variety of open-top cylindrical containers into which the larger and more dense fractions of atmospheric pollutants may settle. In general the state has used standardized plastic containers with screw-on lids for transporting to the laboratory. A fairly large jar with restricted mouth is used to prevent particles from becoming re-entrained into the ambient air by wind. To facilitate retention of particles deposited therein, water with either an algicide for summer usage or anti-freeze in winter months can be used.

The sampling procedure is to place an open-mouth container high on a pole and away from buildings or other structures which would interfere with fallout of particulate from the atmosphere. The container is left for one month, after which the sample is returned to the laboratory where the amount of settleable particulate is determined gravimetrically on an analytical balance. The sample can also be used to determine individual chemical constituents if desired. The grams of particulate per area exposed are then converted to tons/mi^2/mo. Local conditions such as dusty roads can cause results to vary widely and interferences such as leaves, twigs and bird droppings can affect results, but these are partially removed by screening the sample before weighing.

"Replicate samples by various investigators indicate a precision of $\pm$ 15% is attainable for any given combination of collecting element and retention fluid. Results of greater than two to one variation have been found with replicate samples taken by different methods". (Amer. Public Health Assoc. 1972, p 373). Thus the method is not precise. It is however, simple and inexpensive and gives an indication of the amount of settleable particulate in a given area.

Integrating Nephelometer

The integrating nephelometer is comprised of two major assemblies. The first is the sensor unit consisting of the optical assembly with its calibrator, flashtube and two phototubes together with its associated air sampling equipment including ducts, filters and pumps. The second part is the electronic control module containing the necessary amplifiers, power supplies and an indicating meter for monitoring the output from the instrument.

The mechanical assembly is made in a four-inch diameter aluminum tube approximately 44 inches long. The general layout is shown in Figure 4. The flash lamp behind its opal glass screen is mounted on one side of the tube; the multiplier phototube is located in one end of the tube and detects the scattered light from the illuminated air sample; and the light trap and calibration mechanism are situated on the other end.

The reference phototube is mounted in the chamber containing the air volume to be measured. The air to be sampled is drawn into the sampling chamber through an intake duct with the air movement provided by a vacuum blower mounted in the outlet ducting, moving approximately 10 cubic feet of air per minute. This flow rate is not critical and does not affect the visibility readings.

The nephelometer has three scales, indicating the light scattering coefficient ($b_{scat.}$), meteorological range (L_V), and mass concentration (M).

The L_V scale is based on the Koschmieder visibility theory (Charlson 1969) stating that:

$$L_V \simeq \frac{3.9}{550}$$

The relationship between the scattering coefficient at 550 nm (nanometers), b_{550}, and that at 500 nm, b_{500} is:

$$b_{500} = 0.84\ b_{550}$$

Because b_{500} is the quantity indicated by the instrument. The visual range L_V

is then given by

$$L_v\ (m) \simeq \frac{4.7}{b_{500}} = \frac{4.7}{b_{scat}}$$

The meteorological range scale is based on a large number of experiments relating light scattering, mass concentration and visual range as well as the correction factors discussed above. The best current value for the relationship of meteorological range and mass concentration is:

$$L_v \times \text{mass} = 1.8\ g/m^2$$

In order for the units of this expression to come out correctly, L_v is put into meters and mass concentration into grams per cubic meter. This quantity represents the mass of material in a box one meter in cross section and of length L_v. This can be restated in more convenient units where mass represents mass concentration:

$$\text{Mass} = \frac{1.8 \times 10^3}{L_v\ (km)}\ (ug/m^3)$$

Alternatively, the relationship between light scattering coefficient, $b_{scat.}$, as indicated by the primary scale and mass concentration, is:

$$\text{Mass}\ (\mu g/m^3) = 3.8 \times 10^5\ b_{scat}(m^{-1})$$

It is important to state very clearly that the nephelometer measures only light scattering and not mass concentration or visual range. Also, the use of relationships for visual range in terms of mass concentration requires the assumption of a self-preserving particulate size distribution, and such an assumption may not be valid (Ettinger et al. 1972). Nephelometer measurements of visual range and mass concentration in the absence of other on-site supporting measurements (e.g. high volume sampler mass concentrations, etc.) should be interpreted with caution.

The absolute accuracy of the integrating nephelometer is somewhat

difficult to estimate since there is no other instrument for comparison. Studies of the correlation of nephelometer output with visual range as well as theoretical considerations suggest that the calibration is correct to within ± 10%. However, the relative accuracy is perhaps more important since it governs the reproducibility of the measurements. Absolute accuracy cannot affect reproducibility since it is controlled by systematic errors. The relative accuracy is governed by the signal-to-noise ratio which is typically about 20-50 db for scattering by city air. Thus, the overall relative accuracy should be about ± 2 to 5%.

All of the equipment discussed thus far primarily involve particulate sampling. The following equipment primarily measures gas concentration.

<u>Bendix Infrared Gas Analyzer</u>

A Bendix Model 8501-5B infrared gas analyzer is being used to monitor carbon monoxide (CO) levels in the ambient air.

The infrared gas analyzer utilizes the nondispersive single beam technique, with alternate modulation of the sample and reference cells. The principal of measurement is based on the known characteristic absorption spectra of CO in the infrared range. The reference cell is filled with a nonabsorbing gas and sealed, and the sample is passed through the sample cell. With no CO present in the sample, the amounts of radiation coupled into the detection chamber from the sample and reference cells would be essentially equal, effectively cancelling and producing no output. When CO is present in the sample, it absorbs some radiation, causing inputs to be unequal, and producing an output signal from the detection chamber. The detection chamber is designed so that the output is proportional to the concentration of CO. The output is transcribed as a trace on a strip chart.

The ambient sample is passed through particle filters before it enters the detection cell so that tne absorption process if not contaminated by dust.

<u>Bendix Ozone, NO and NO_x Monitors</u>

Ambient air concentrations of ozone (O_3) and oxides of nitrogen (NO_x) are

monitored by Bendix Corporation instruments which utilize the principal of photometric detection of chemiluminescence resulting from flameless reactions between the substance being monitored and a co-reactant.

Chemiluminescence is the production of light waves or photons as a result of flameless phase reactions between the substances. These photons are transmitted to a photomultiplier tube in numbers proportional to the amount of NO, NO_x, or O_3 drawn into the process from the ambient air. The tube converts the light energy of the photons into electrical energy which is further amplified by the electrometer amplifier to provide proper drive voltages for the panel meter and strip chart recorder. Thus, the resulting readings are proportional to the light produced by the flameless reaction, which in turn is proportional to the ambient concentration of O_3, NO, or NO_x, whichever is being measured.

The ozone monitor utilizes the flameless phase reaction between ozone and ethylene, while the NO, NO_x monitor utilizes the reaction between NO and O_3. In both monitors the ambient air is passed through particulate filters, then into the reaction chamber where it is combined with its co-reactant.

Philips PW 9700 SO_2 Monitors

Ambient air SO_2 concentrations were measured coulometrically by a Philips PW 9700 SO_2 monitor.

Before entering the detector cell, the air to be monitored for SO_2 must be free of dust, ozone, hydrogen sulfide, and other materials that might interfere. Dust is removed by a fiber filter in the sampling head and the other substances are removed by a silver filter inside the chemical unit. The cleaned air is then passed through an aqueous solution of potassium bromine (KBr), bromine (Br_2), sulfuric acid (H_2SO_4), at the rate of about 150 ml/min. SO_2 in the air reacts with the solution to ionize the bromine, resulting in current flow between two electrodes. The current flow reunites the ions into free bromine.

The amount of current needed for this reaction is directly proportional to the quantity of bromine ionized, which in turn is directly proportional to the

quantity of SO_2 which flows through the cell and reacts with the bromine. The amount of SO_2 in the ambient air thus can be recorded in terms of the amount of current drawn by the process. Air flow is kept constant with the aid of a critical orifice and a vacuum pump.

Bubble Sampling (NO_2 and SO_2)

Atmospheric NO_2 and SO_2 concentrations are monitored both by continuous analyzers and bubbler methods. The sampling procedure for both pollutants is the same except for the absorbing solution. Ambient air is drawn into a polypropylene tube and bubbled through the absorbing solution. The air flow is maintained around 200 ml/min. by a critical orifice. Both the orifice and the pump that maintains pressure on the orifice are protected by a moisture trap and a particulate filter. Pressure is being checked before and after a sample is taken, and the critical flow through the orifice is checked between samples. After collection the samples are refrigerated until they are mailed to Helena for chemical analysis.

Nitrogen dioxide is collected by bubbling ambient air through a solution of sodium hydroxide and sodium arsenite. The nitrite ion concentration produced during sampling is determined colormetrically by reacting the exposed absorbing reagent with sulfanilamide and N-1 naphthylethylene diamine dihydrochloride.

The sample is run 72 hours. Fifty mls of absorbent solution allows detection of 5 to 750 μg of NO_2 per cubic meter of air for 72 hours at 200 ml per minute.

Sulfur dioxide is absorbed from ambient air in a solution of potassium tetrachloramecurate (TCM). A dichlorosulfitomercurate complex is stable in the presence of strong oxidants. The complex is reacted with pararosaniline and formaldehyde to form intensely colored pararosaniline methyl sulfonic acid. The absorbence of the solution is measured spectrophotometrically.

Fifty mls of TCM allows a range of 25 to 1050 μg of SO_2 per cubic meter of air over a 24-hour period of 200 ml/min. flow.

All bubble samples have been 72 hour samples.

Sulfation Plates

The sulfation plate for determining SO_2 concentrations is made by attaching a 4.8 centimeter diameter Gelman A fiberglass filter to a 4.8 centimeter diameter petri dish with three drops of acetone. The lead dioxide solution to coat the petri dish is made in the following manner: 112 grams of lead dioxide is blended in a blender with 700 milliliters of water, 0.7 grams of gum tragacanth, and 7 grams of fiberglass filter ground on a Wiley mill to pass 20 mesh. Ten milliliters of this material is transferred into each petri dish. The coated dish is dried in an oven at low temperature (60°C) and sealed with a lid.

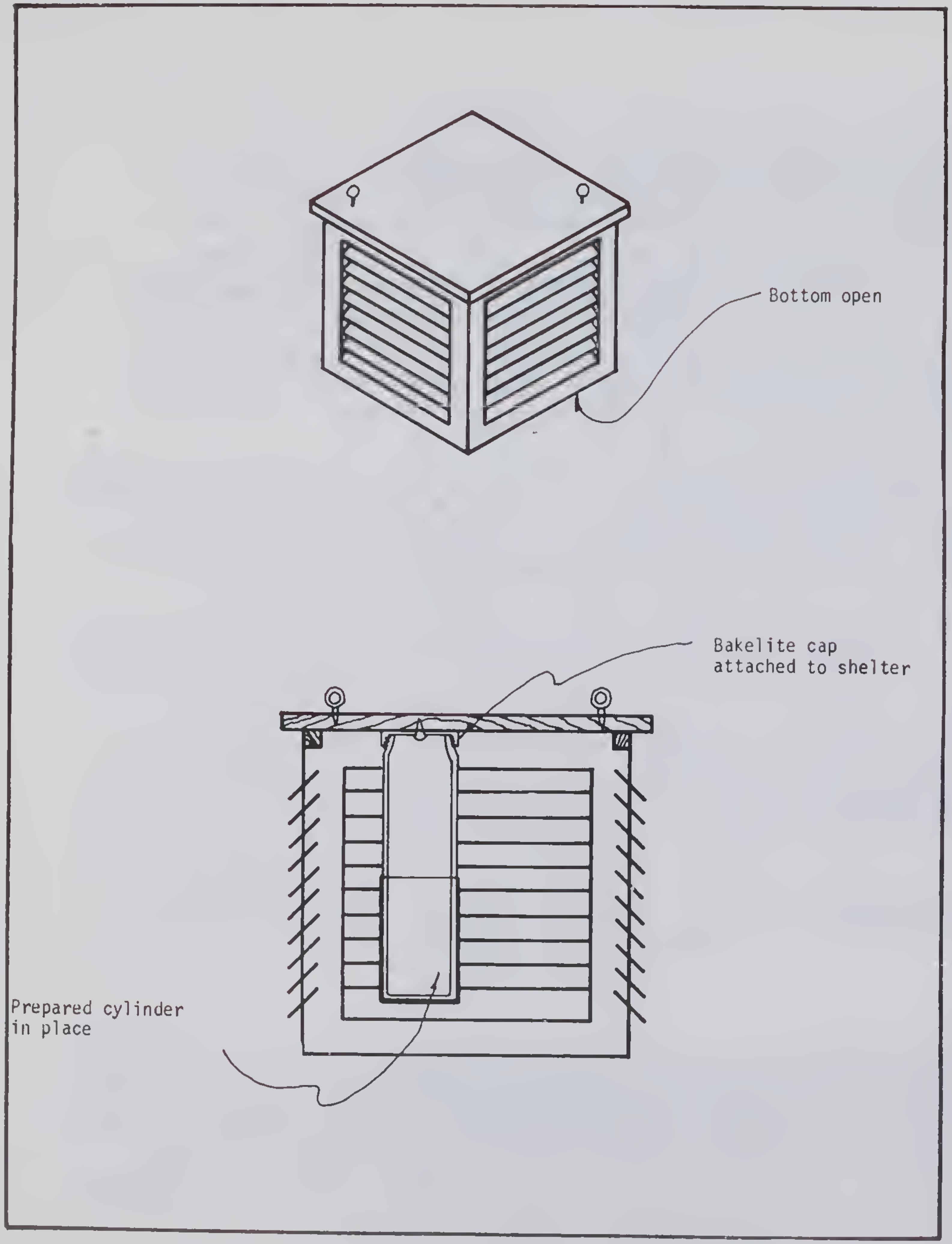
To expose a sulfation plate, the lid is removed and the plate is placed in a bracket that will secure the sulfation plate upside-down (Figure 5). The petri dish serves as the shelter, shipping container, and lead dioxide support. The sulfation plate is exposed for approximately 30 days.

After exposure, the lead dioxide is removed from the petri dish with a small amount of water. The insoluble lead sulfate is converted to soluble sodium sulfate with the aid of 20 ml of sodium carbonate solution (50 grams/liter) and heat. The excess insoluble lead dioxide is removed by filtration. The solution is acidified with hydrochloric acid to bring the pH of the filtrate between 2 and 3. The acidified filtrate is diluted to 50 ml or any other convenient volume with water. A portion of this solution (up to 25 ml) is then diluted with 25 ml of water. To this, 0.1 gram of sulfur powder is added, mixed, and let stand 20 minutes. The resulting turbidity is measured in a spectrophotometer at 450 millimicrons.

Sodium Formate Plates

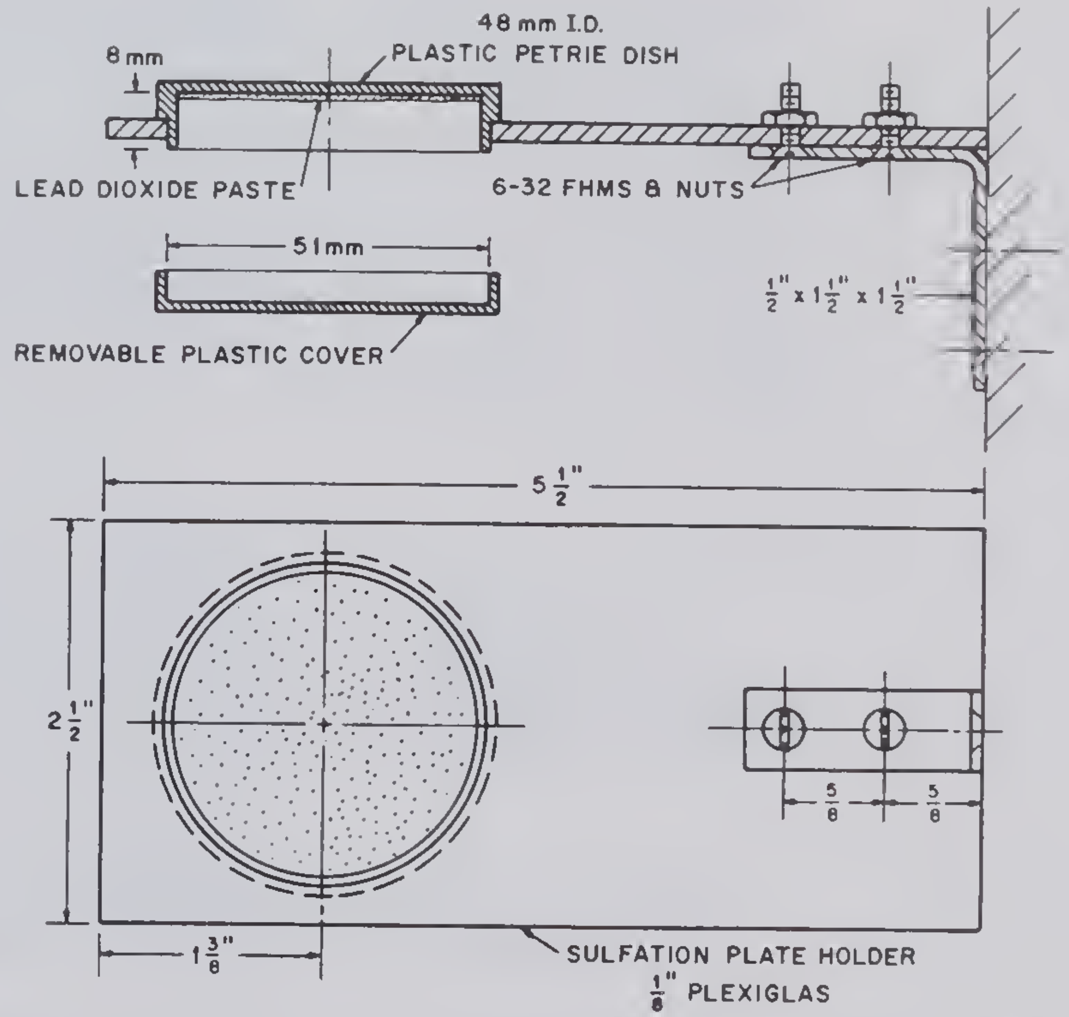
This sampling technique is used to measure monthly levels of fluoride in the air. The fluoride collection media used is a Whatman 41 filter paper (4.7 cm diameter) attached to a petri dish with three drops of acetone. The filter discs are immersed in a 50% ethyl alcohol solution containing 10% sodium formate. These discs are air dried at room temperature in a fluoride free area.

To expose the fluoride plate, the lid is removed and the plate is placed in a bracket that will secure the fluoride plate upside-down (Figure 5). The petri dish serves as the shelter, shipping container, and



Standard Louvered Shelter (Montana Box)

FIGURE 6



Sulfation Plate and Holder

FIGURE 5

fluoride slate support. The fluoride plate is exposed for approximately 30 days.

The exposed filter paper is removed from the petri dish and placed in a 100 ml polyethylene beaker. The filter paper is covered with 20 ml of distilled water and let stand for 2 hours. Next 20 ml TISAB buffer solution is added and the fluoride concentration is read on the fluoride electrode as the solution is stirred with a magnetic stirrer.

The range of measurement of the fluoride electrode is .019 to 19,000 ppm soluble fluoride. However, the recommended range of analysis for air samples is between 0.1 and 10 ppm.

Calcium Formate Papers

Ambient air samples for fluoride are collected with the use of filter paper impregnated with calcium formate. The 11 centimeter filter papers are prepared by soaking Whatman No. 2 papers in a solution of 10% calcium formate (10 grams calcium formate dissolved in 100 ml distilled water) for approximately 5 minutes and drying them in a forced air oven set at approximately 80°C for about one hour or letting them dry overnight in a room free of fluoride.

The filter papers impregnated with calcium formate solution are exposed in a standard louvered shelter (Montana box) for approximately 30 days (Figure 6). The shelters give protection from normal rainfall and snow, while permitting free flow of air over the papers. They are installed about 2 meters above the ground, clear of shielding objects.

After the papers have been exposed for approximately 30 days, they are fired in inconel crucibles in a muffle furnace for approximately one hour at 600°C. The ashed papers are dissolved with 100 ml of 1-1 $HClO_4$ and diluted to 250 ml with distilled water. Using the auto-analyzer, the solution and sulfuric acid are pumped into the Teflon coil of a microdistillation device maintained at 170°C. A stream of air carries the acidified sample swiftly through a coil of teflon tubing to a fractionation column. The fluoride and water vapor distilled from the sample are swept up the fractionation column into a condenser and the condensate passed into a small collector. The distillate is pumped continuously from the sample

collector. Acid and solids are removed from the bottom of the fractionation column and are drawn to waste. The distillate is mixed continuously with alizarin fluorine blue-lanthanum reagent, and the colored stream passes through a 15 mm tubular flow cell of a colorimeter, where transmittance is measured at 620 μ. The impulse is transmitted to a recorder.

This method can detect values as low as 0.1 ug F/ml. The operating range of the recorder is 0.1-2.0 μg F/ml. Higher concentrations must be diluted with a 1 to 1 solution of $HClO_4$.

QUALITY CONTROL

Calibration procedures were conducted and quality control techniques were incorporated into the sample collection and service program according to EPA guidelines. The following is a general discussion by sampler of the methods used to insure quality of the data as specified by EPA (1973).

1. High Volume Filter Collection

All filters were marked prior to exposure for identification and instruments were calibrated prior to and after collection of sample to measure flow changes. Total volume of air flow was strictly logged with each filter. Filters were handled carefully and kept clean to avoid contamination. Filters were mailed in special sealed envelopes to avoid loss of collected material from the filters.

2. Continuous Monitors (SO_2, CO, O_3)

The monitors were periodically calibrated. Drift in baseline was strictly logged and baseline drift over a 24-hour period greater than $\pm$ 2% invalidated the data. Only certified permeation tubes or span gases were used in calibrations.

3. Bubblers

Volume of sample used and the micrograms of pollutant sampled were strictly checked. Hypodermic needles used in sample collection were calibrated before and after sample collection. Samples were mailed in wooden protector boxes to avoid damage.

4. Indicators

Calcium formate papers were handled only by forceps or very clean hands and only by the extreme edges. When transporting, papers were enclosed in sterile plastic bags or glycine envelopes and sealed. In the laboratory analysis, with every eleven samples analyzed, an unexposed paper was also analyzed to detect contamination. The auto-analyzer was calibrated prior to every run.

As for sodium formate plates, the sample was contained in a covered plastic petri dish before and after exposure. An unexposed plate was also run with exposed plates for detection of contamination. The instrument was calibrated prior to runs. Sulfation plates followed the same procedure as sodium formate plates in quality control.

Dustfall measuring jars were covered prior to and after sample collection. Excessive interference to weighing such as bird droppings or insects in the buckets invalidated some samples.

5. Meteorological Data

Wind data was read from strip charts and any inconsistencies in the data were noted in a logbook by the technician along with comments as to the validity of the data. Temperature and relative humidity data followed the same procedures. The instrument was also periodically calibrated by an aspirated psychrometer. Nephelometer readings followed the same general procedure as the wind instrument. Calibrations were performed periodically. Solar radiation and ultra-violet radiation instruments required occasional washing and cleaning of the diffusion discs. Instruments were also checked to insure levelness. Processing of the data followed the same general procedure as previously mentioned instruments.

All chemical analyses were performed in laboratory facilities in Helena by HES staff and all analyses methods used were considered state-of-the-art. A lab and field technician, located in Colstrip, routinely serviced and maintained all instruments and recorded rigid documentation of all service calls and calibration. Frequent reviews and checks of field procedures and instruments were made by personnel from the HES office.

Most of the monitors were installed between November 1, 1973 and December 15, 1973. Calibration of the instruments was conducted prior to installation or within 1½ months after installation.

Sample Analysis

Charts and samples collected at the various sites in the Colstrip area were routinely sent by mail or by vehicle to the Air Quality Bureau in Helena for analysis. Comments by the on-site technician were written on each chart as to the validity of the data. Also any circumstances in the weather that might alter readings were reported. When charts were received at Helena, they were read and values were transferred directly to SAROAD forms (EPA standard forms for Storage and Retreival of Aerometric Data). If there were any comments causing data to be questionable or during periods when instruments were not working properly, the data were invalidated. Samples that were collected for laboratory analysis were marked when received and then sent directly to the laboratory.

After a month's data were recorded on the SAROAD forms, it was sent to the State Department of Administration, Data Processing Bureau, for keypunching and verifying. Following this the data was run through the State Department of Highways IBM Systems 370 computer with various programs. Computer programs were written by Air Quality Bureau personnel to be general enough to accept several different forms of data and yet present the data in a summary form that was meaningful. Data were also checked in the computer programs for errors in station code, dates, and sequence of the data. Following the summary by the computer programs, the printout sheets were examined for inconsistencies in the data or any other obvious errors. Any values that appeared questionable were verified either from laboratory records or from strip charts.

The computer programs with the exception of the wind rose program were all written in Fortran IV programming language. The wind rose program was written in American National Standard Cobol programming language by HES.

The programs computed means (geometric and arithmetic), maximum concentrations, and summaries of the current month's data, year-to-date data, and a 12-month running year summary. Also, in some programs values were checked to see if the ambient air quality standards or other significant pollutant levels were exceeded.

A3: AIR QUALITY STANDARDS

TABLE 1

NATIONAL AMBIENT AIR QUALITY STANDARDS

POLLUTANT	PRIMARY STANDARD	SECONDARY STANDARD
1. Sulfur Oxides	80 ug/m^3 (0.03 ppm) annual arith. mean 365 ug/m^3 (0.14 ppm) max 24 hr. conc. not to be exceeded more than once a year.	1300 ug/m^3 (0.5 ppm) max 3 hr. conc. not to be exceeded more than once a year.
2. Particulate Matter	75 ug/m^3 annual geom. mean 260 ug/m^3 max 24 hr. conc. not to be exceeded more than once a year.	60 ug/m^3 annual geom. mean,* 150 ug/m^3 max 24 hr. conc. not to be exceeded more than once a year.
3. Carbon Monoxide	10,000 ug/m^3 (9 ppm) max 8 hr. conc. not to be exceeded more than once a year.	Same as primary
	40,000 ug/m^3 (35 ppm) max 1 hr. conc. not to be exceeded more than once a year.	Same as primary
4. Photo Chemical Oxidants (corrected for NO_2 and SO_2 interference)	160 ug/m^3 (0.08 ppm) max 1 hr. conc. not to be exceeded more than once a year.	Same as primary

* To be used as guide in assessing State Implementation Plans.

TABLE 1
(continued)

POLLUTANT	PRIMARY STANDARD	SECONDARY STANDARD
5. Hydrocarbons (corrected for CH_4)	160 ug/m^3 (0.24 ppm) max 3 hr. conc. (6 to 9 a.m.) not to be exceeded more than once a year.	Same as primary
6. Nitrogen Oxides (as Nitrogen Dioxide)	100 ug/m^3 (0.05 ppm) annual arith. mean.	Same as primary

TABLE 2

Ambient Air Quality Standards - Montana

POLLUTANT	STANDARD				
	Annual	Month	24-hour	1/2 hour	1 hour
Particulate, ug/m^3	75 geometric mean (G.M.)	-	200 1% of time*	-	-
SO_2 ppm	0.02 arithmetic mean (A.M.)	-	0.10 1%/3 months*	-	0.25 once/4 days*
, sulfation-mg SO_3/100 cm^2/day	0.25	0.50	-	-	-
, sulfate-ug/m^3	4	-	12-1% of time	-	-
H_2SO_4 ug/m^3	4	-	12-1% of time	-	30 1% of time*
H_2S, ppm	-	5.0	-	0.03 twice/5 days* 0.05 twice/year*	-
Pb, ug/m^3	-	5.0	-	-	-
Be, ug/m^3	-	0.01	-	-	-
Fl, total as HF - ppb	-	-	1	-	-

TABLE 2 (cont)

POLLUTANT	STANDARD				
	Annual	Month	24-hour	1/2 hour	1 hour
Fl, as F in forage, ppm w	35	-	-	-	-
, gaseous - ug/cm^2	-	-	-	-	-

* not to be exceeded more than

New Source Performance Standards (NSPS)

The Federal Clean Air Act mandated that the EPA from time to time establish standards of performance for a category of sources whose emissions the Administrator feels may cause or contribute significantly to endangerment of the public health or welfare. This "standard" must reflect "the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated." On December 23, 1971, EPA promulgated standards of performance for fossil fuel-fired steam generators. The heat input rating, i.e., the heating value of the fuel introducted to the unit, must be greater than 250 million BTU per hour in order for the regulation to apply. This is equivalent to about a 25 megawatt plant. Any plants under construction or modification to existing plants after August 17, 1971, must conform to the limits shown below.

TABLE 3: NSPS for Steam Generators

	Allowable Emissions		
	Fuel-Fired		
	Coal	Oil	Gas
Particulate, $\#/10^6$ BTU	0.10	0.10	0.10
Particulate, opacity	20%	20%	20%
Sulfur Dioxide, $\#/10^6$BTU	1.20	0.80	--
Nitrogen Oxides, $\#/10^6$BTU	0.70	0.30	0.20

TABLE 4

Emission Regulations - Montana

A. Fuel Combustion - Particulate Matter

10^6 BTU/hr. Fuel Heat Input	(1) #Particulate/10^6 BTU Existing Source	(2) New Source
10	0.6	0.6
100	0.4	0.35
1,000	0.28	0.20
10,000	0.19	0.12

B. Fuel Combustion - Sulfur Compounds

Effective Date	Pollutant	Allowable Emissions
July 1, 1972	SO_2	1.0 #S/10^6 BTU
July 1, 1971	H_2S	50 grains/100 ft^3

C. Visible Emissions

Existing Source	40 percent opacity
New Source	10 percent opacity

(1) Interpolate between values
(2) After November 23, 1968

A4 Meteorology Data

Table 1

The following table provides information concerning the probability of a longer or shorter freeze-free season than average.

Probability That The Freeze-Free Season Will Be At Least

30 days less
than average length.....5% or 1 year in 20

23 days less
than average length.....10% or 1 year in 10

13 days less
than average length.....25% or 1 year in 4

Average Length..........50% or in half the years

13 days longer
than average length.....25% or 1 year in 4

23 days longer
than average length.....10% or 1 year in 10

30 days longer
than average length.....5% or 1 year in 20

(Caprio 1964)

TABLE 2

LATITUDE 45° 53'N
LONGITUDE 106° 36'W
ELEV. (GROUND) 3,221 ft.

CLIMATOLOGICAL SUMMARY

STATION COLSTRIP, MONTANA

MEANS AND EXTREMES FOR PERIOD 1941-1970

Month	Temperature (°F)							**	Precipitation Totals (Inches)								Mean number of days					Month
	Means			Extremes								Snow, Ice Pellets						Temperatures				
																		Max.		Min.		
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Mean degree days	Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Greatest daily	Year	Precip. .10 inch or more	90° and above	32° and below	32° and below	0° and below	
(a)	30	30	30	30		30		20	30	30		30	30		18							
JAN.	34.2	7.7	21.0	67	1953	-40	1954	1356	.56	.62	1943	5.8	11.7	1963	5.5	1946	2	0	11	30	10	JAN.
FEB.	39.8	13.9	26.9	70	1958	-31	1965	1053	.56	.55	1965	5.8	13.3	1955	6.0	1959	2	0	7	27	6	FEB.
MAR.	45.8	18.9	32.3	80	1943	-28	1945	1001	.74	.95	1943	6.0	15.5	1942	5.0	1954	2	0	5	28	3	MAR.
APR.	59.3	30.1	44.7	87	1962+	3	1947+	624	1.86	2.82	1969	5.1	19.0	1955	8.0	1963	5	0	*	19	0	APR.
MAY	69.2	39.4	54.3	96	1948	13	1954	319	2.47	2.15	1946	*	3.0	1953	2.0	1954	6	1	0	5	0	MAY
JUNE	77.6	47.7	62.7	102	1961	28	1964	105	3.31	3.77	1944	*	8.0	1951	8.0	1951	7	3	0	*	0	JUNE
JULY	89.2	53.8	71.5	107	1960	34	1961	12	1.18	1.33	1962+	0	0	----	0	----	3	17	0	0	0	JULY
AUG.	88.1	52.1	70.1	111	1961	33	1966	24	1.39	1.83	1964	0	0	----	0	----	3	15	0	0	0	AUG.
SEP.	75.9	42.0	59.0	102	1960+	18	1942	203	1.38	1.88	1945	*	7.0	1950	7.0	1950	3	4	0	4	0	SEP.
OCT.	64.8	32.4	48.6	94	1963	7	1941	500	1.04	2.07	1958	2.0	13.1	1946	8.0	1946	3	*	*	15	0	OCT.
NOV.	47.5	21.1	34.3	79	1965	-32	1959	915	.67	1.18	1957	3.1	14.0	1941	8.0	1957	3	0	3	26	2	NOV.
DEC.	38.2	12.8	25.5	71	1957	-35	1964	1202	.63	.58	1958	6.8	15.6	1964	9.5	1958	2	0	9	30	6	DEC.
Year	60.8	31.0	45.9	111	AUG. 1961	-40	JAN. 1954	7314	15.79	3.77	JUNE 1944	34.6	19.0	APR. 1955	9.5	DEC. 1958	41	40	35	184	27	Year

(a) Average length of record, years.

T Trace, an amount too small to measure.

** Base 65°F

+ Also on earlier dates, months, or years.

* Less than one half.

Greatest daily snow for period 1946-1963

TABLE 3

Average Three Hour Relative Humidity (Per Cent)

Hour (MST)

Month & Year		2	5	8	11	14	17	20	23	AVG
January	72	66	63	63	57	54	61	68	69	63
February	72	70	72	71	57	53	57	64	67	64
March	72	67	64	58	40	36	38	59	66	53
April	72	70	72	53	39	32	34	53	66	52
May	72	67	68	51	41	37	36	57	68	53
June	72	69	72	44	33	29	33	48	65	49
July	72	67	72	47	34	27	28	40	58	47
August	72	72	73	49	34	28	28	49	68	50
September	72	67	71	53	34	29	32	51	63	50
October	72	77	79	70	44	40	47	72	78	63
November	*	76	79	77	56	47	59	74	75	68
December	71	73	73	74	59	54	64	69	72	67

* 13-30 November 71
1-12 November 72

Source = Heimbach et al., 1974

TABLE 4

Average Three Hourly Temperatures (Deg F)

Hour (MST)

Month & Year		2	5	8	11	14	17	20	23	AVG
January	72	14	15	14	19	20	17	14	14	16
February	72	20	19	20	28	32	29	24	23	24
March	72	31	30	34	44	48	47	37	33	38
April	72	36	34	43	51	54	52	43	38	44
May	72	46	46	56	62	65	63	53	48	55
June	72	56	54	68	75	79	75	66	59	67
July	72	55	53	66	75	79	77	67	59	66
August	72	57	56	70	79	83	81	67	59	69
September	72	45	43	54	65	67	64	52	47	55
October	72	35	34	39	52	53	48	38	36	42
November	*	32	31	31	41	43	38	33	32	35
December	71	15	14	13	22	26	21	18	16	18

* 13-30 November 71
1-12 November 72

Source = Heimbach et al., 1974

TABLE 5

Average Three Hourly Dewpoint Temperatures (Deg F)

Hour (MST)

Month & Year		2	5	8	11	14	17	20	23	AVG
January	72	4	4	3	5	6	5	5	5	4
February	72	11	10	12	14	15	15	13	12	13
March	72	21	19	20	20	20	20	23	22	21
April	72	26	25	26	24	22	21	25	26	25
May	72	34	35	36	35	34	32	37	38	35
June	72	45	45	45	44	43	42	44	47	44
July	72	43	44	44	42	40	39	40 43	43 40	42 43
August	72	48	47	49	47	44	42	46	48	46
September	72	34	33	36	34	31	30	33	34	33
October	72	28	27	30	28	27	26	29	29	28
November	*	24	24	24	25	23	24	25	25	24
December	71	7	6	6	9	10	10	9	7	8

* 13-30 November 71
1-12 November 72

Source = Heimbach et al., 1974

TABLE 6

Average Three Hourly Wet Bulb Temperatures (Deg F)

Hour (MST)

Month & Year		2	5	8	11	14	17	20	23	AVG
January	72	12	12	11	15	17	14	12	12	13
February	72	17	16	18	24	26	24	21	20	21
March	72	27	26	29	35	37	36	31	29	31
April	72	32	31	36	40	41	40	36	33	36
May	72	41	41	46	49	50	48	45	43	45
June	72	50	50	55	57	59	57	54	53	54
July	72	49	48	54	57	57	57	53	51	53
August	72	52	51	58	60	61	59	55	53	56
September	72	40	39	45	50	50	48	43	41	44
October	72	32	31	35	41	42	39	35	33	36
November	*	29	28	29	35	35	32	30	30	31
December	71	13	12	12	19	22	18	15	13	15

* 13-30 November 71
1-12 November 72

Source = Heimbach et al., 1974

Data presented in Tables 7-9 and Figures 1 and 2 were collected by U. S. Weather Service stations, State Department of Health and Environmental Sciences (HES) Monitoring data, and the Earth Sciences Department of Montana State University.

Table 7 summarizes climatological data collected by HES from October 1973 to June 1974.

Table 8 summarizes HES solar radiation measurements in the Colstrip area. Both ultra-violet and solar radiation were measured with highest readings in the 12:00 noon to 2:00 p.m. range. Minimum values of 0 indicate stormy or extremely cloudy days.

Table 9 shows average visibilities as recorded at two sites near Colstrip. Also shown are minimum visibilities and corresponding relative humidity readings for several shorter time periods. Visibilities were recorded by an integrating nephelometer and in most cases are farther than the human eye can see at ground level due to the earth's curvature. Visibilitieson the average were greater at the BN site, but the BN site also recorded the lowest short time visibility of 3 miles.

Figures 7 and 8 summarize hourly wind speed and direction data collected at two sites near Colstrip. The wind roses show that slower wind speeds most often occur from a southerly direction. The higher wind speeds are recorded in the north to west directions. The data includes approximately eight months of data.

TABLE 7

HYGROTHERMOGRAPH DATA
McRae Site
1973 - 1974

MONTH	AVER. TEMP. DAILY MAX.	AVER. TEMP. DAILY MIN.	AVER. TEMP. MONTHLY	EXTREMES (TEMP) HI	DATE	LOW	DATE	DEGREE DAYS (BASE 65) HEATING	DEGREE DAYS (BASE 65) COOLING
OCT +	--	--	--	35	31	28	31	0	0
NOV	40	22	30	60	10	10	6	803	0
DEC	36	20	29	50	16	10	15	761	0
JAN	42	27	34	51	17	11	6	395	0
FEB	41	23	32	55	26	14	1	663	0
MAR	45	27	35	62	27	10	19	627	0
APR	54	36	45	80	25	23	4	470	2
MAY	56	37	46	76	26	29	13	408	0
JUNE	74	50	63	94	19	33	1	134	70
YEAR	53	21		94		10		4261	72

TABLE 7 (cont)

MONTH	Rel. Hum. HR 06	HR 12	HR 18	HR 24	Days Max Temp 90^{o} & Over	32^{o} & Over	Days Min Temp 32^{o} & Below
OCT+	--	--	54	100	--	--	--
NOV	86	62	63	81	0	5	23
DEC	80	68	67	77	0	6	21
JAN	87	80	74	84	0	1	11
FEB	90	78	63	85	0	2	20
MAR	88	74	68	88	0	3	16
APR	93	79	60	80	0	0	7
MAY	94	72	65	85	0	0	2
JUNE	94	67	54	78	2	0	0
YEAR					2	17	100

*** Averages, degree days, and days max and min temp are based on days with 20 or more hours data.
*** Degree day is defined as the daily average temp-65 where negative values indicate heating days.
*** Relative humidity values are averages of the relative humidity at the hour indicated over the entire month.
*** Range limits of instrument are from 10 to 110 deg. F and 0 to 100 percent RH.

Data outside these limits are considered invalid and eleminated.
+ Only one day of data collected.

TABLE 8

Radiation Measurements
McRae Site
Operational Period: Nov. 73 - June 74

	Ultra-violet* Radiation (Photometer)	Solar Radiation+ (Quantum Sensor) Sampler I	Sampler II
10AM Arith. Aver.	15	455	604
Std. Dev.	8	249	332
Max. Value	58	1972	2329
Min. Value	0	0	0
No. Readings (1-hr)	174	173	173
12 Noon Arith. Aver.	28	749	989
Std. Dev.	13	355	492
Max. Value	70	1836	2449
Min. Value	0	0	0
No. Readings (1-hr)	173	172	172
2 PM Arith. Aver.	30	774	1093
Std. Dev.	13	353	521
Max. Value	76	1972	2690
Min. Value	0	0	0
No. Readings (1-hr)	172	162	171
4 PM Arith. Aver.	25	692	921
Std. Dev.	11	297	405
Max. Value	64	1700	2208
Min. Value	0	0	0
No. Readings (1-hr)	173	172	172

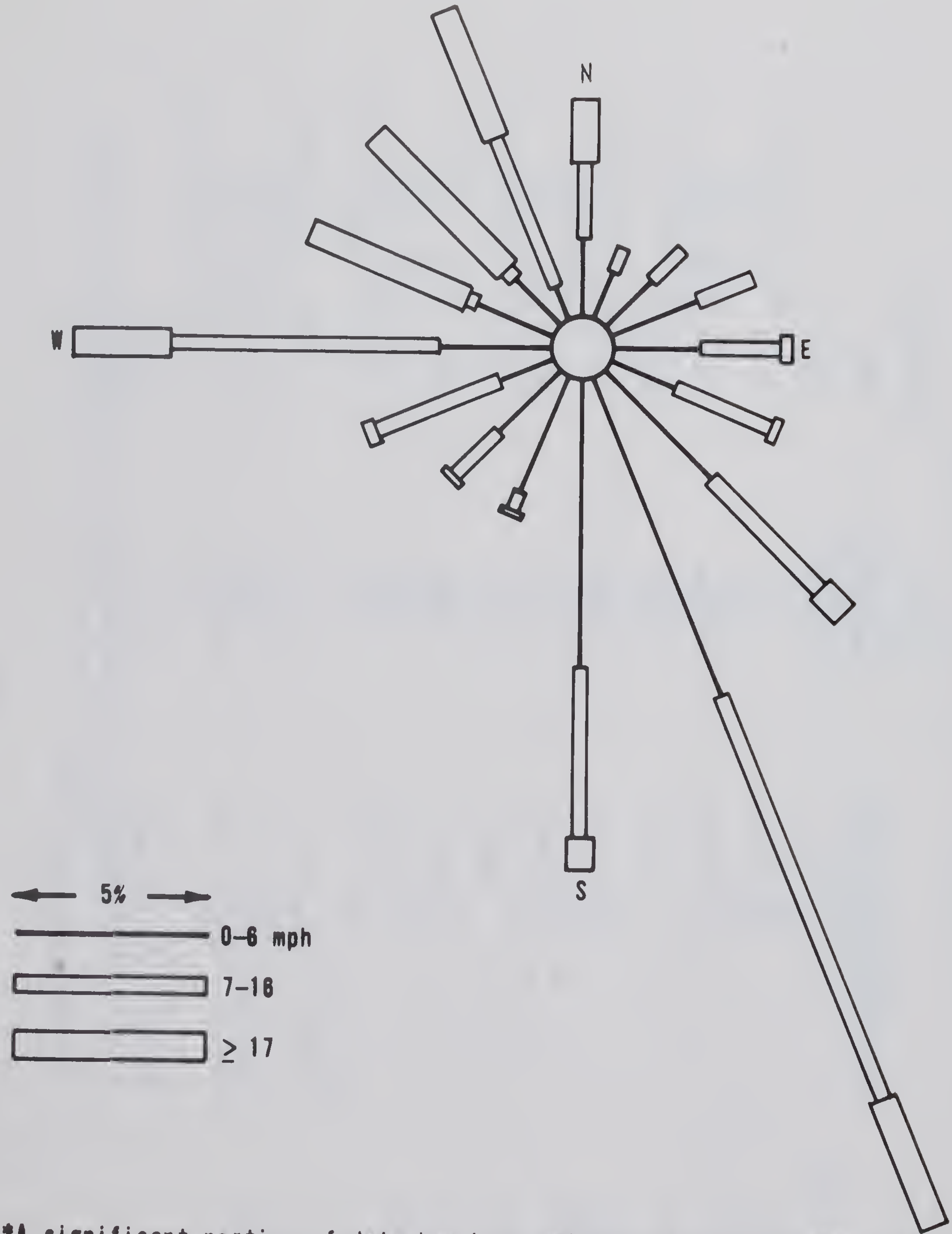
* Values in millicalories per square centimeter per minute
+ Values in microeinsteins per square meter per second

TABLE 9

Visibility Measurements
Values in Linear Miles

		BN Site	McRae Site
Arithmetic Avg.	(Total)	381.5	256.5
"	(Oct.)	406.4	106.4
"	(Nov.)	398.1	425.0
"	(Dec.)	491.7	226.2
"	(Jan.)	530.9	314.9
"	(Feb.)	535.6	273.8
"	(Mar.)	383.9	262.6
"	(Apr.)	267.4	210.4
"	(May)	162.0	222.4
"	(June)	185.9	186.5
Min. 1-hr/ corres. relative hum*		3.0/100	11.2/99
Min. 3-hr/ corres. relative hum*		3.0/100	16.7/99
Min. 24-hr/ corres. relative hum*		59.6/90	35.2/80
Total Readings Taken		5272	5577

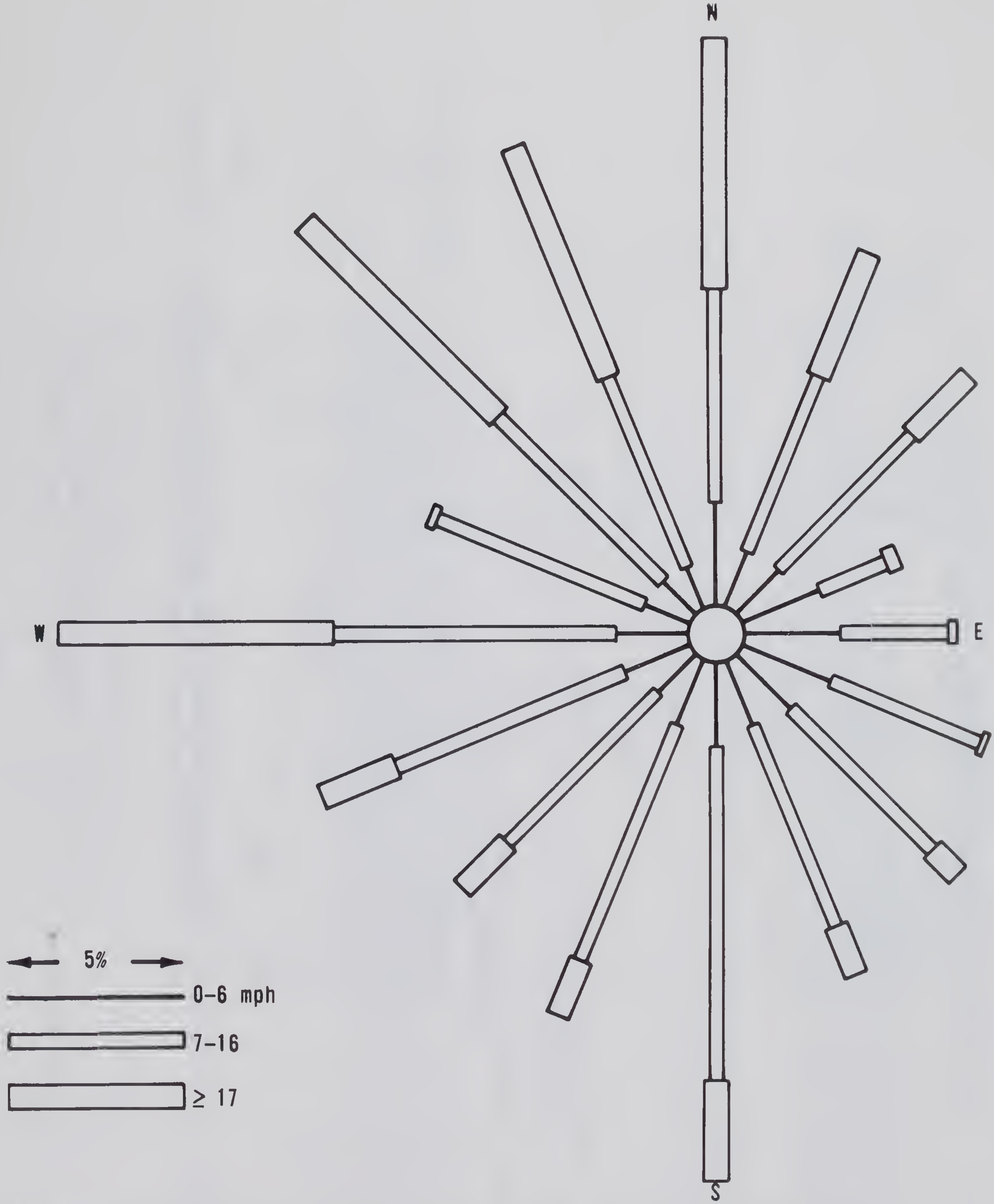
*RH data from McRae Site



*A significant portion of data has been omitted due to instrument failure.

SDHES HOURLY WIND DATA
McRae Site
Oct. 73 - June 74*

FIGURE 1



*A significant portion of data has been omitted due to instrument failure.

SDHES HOURLY WIND DATA
BN Site
Oct. 73 – June 74*

FIGURE 2

A5 Pasquill Stability Class Criteria

Pasquill Stability Category	AEC's $\frac{\partial\theta}{\partial Z}$ ($^{o}C/100m$)	MSU's $\frac{\partial\theta}{\partial Z}$ ($^{o}C/100m$)	MSU's $\frac{\partial T}{\partial Z}$ ($^{o}C/100m$)
A			
	-0.92	-0.43	-1.41
B			
	-0.72	-0.37	-1.35
C			
	-0.52	-0.30	-1.28
D			
	+0.48	+0.28	-0.70
E			
	+2.48	+1.53	+0.55
F			
	+4.98	+3.51	+2.52
G			

The temperatures used to calculate lapse rates by MSU were measured at 18 m and 90m AGL. Super et al. (1973) reported that a personal communication indicated that the AEC lapse rate criteria applied to the layer from about 10 to 50m AGL. The AEC lapse rate criteria were therefore modified to correspond to the actual heights at which temperatures were measured using the following equation.

$$\left.\frac{\partial\theta}{\partial Z}\right]_{\overline{Z}_2} = \left.\frac{\partial\theta}{\partial Z}\right]_{\overline{Z}_1} (\overline{Z}_2/\overline{Z}_1)^b \qquad \text{(A5-1)}$$

The exponet b was allowed to vary with height. See Super et al. (1973) for more details of the calcualtions.

A6 Colstrip Near-dawn Effective Plume Height Method of Calculation

The plume rise from Units 3 & 4 was calculated using the data contained in Air Pollution Potential Determination for Colstrip, Montana (Super, et al. 1973) and the equations developed by Briggs (1969) described in Appendix A11. The following data were available for each near-dawn groundbased inversion and/or isothermal layer (Super, et al. 1973):

1) Date and time at the beginning of the temperature sounding.

2) Height of the top of the inversion and/or isothermal layer.

3) Temperature at the top layer.

4) Hourly surface temperature corresponding to the nearest hour of the time of the beginning of the sounding.

5) Mean hourly 307 ft. wind corresponding to the nearest hour of the time of the beginning of the sounding.

The layer top height, layer top temperature, and surface temperature were used to calculate a mean temperature change through the layer. The change in potential temperature through the layer was then calculated using the following expression:

$$\frac{\Delta \theta}{\Delta Z} = \frac{\Delta T}{\Delta Z} + .977 \ ^{0}C/100m \qquad (A6\text{-}1)$$

where

$\frac{\Delta \theta}{\Delta Z}$ = is the change in potential temperature through the layer

$\frac{\Delta T}{\Delta Z}$ = is the cange in temperature through the layer and

.977 ^{0}C/100m is the adiabatic lapse rate.
The mean change in potential temperature together with the surface

temperature and the 307 ft. wind speed were then imput to Briggs' equation for plume rise in a stable atmosphere. The calculated effective plume height was then compared with the top height of the layer. If the latter exceeded the former the plume centerline was assumed to remain in the stable layer.

A7 TURBULENT DIFFUSION EQUATION

As given by Mathis et al. (1973), the turbulent diffusion equation is:

$$\frac{\partial \overline{C_i}}{\partial t} + \nabla \cdot \overline{C_i u} + \nabla \cdot \overline{C_i' u'} = D_{ij} \nabla^2 \overline{C_i} + R_i(\overline{C_1} + C_1', \ldots, \overline{C_n} + C_n') \qquad \text{(A7-1)}$$

Where: C_i is the concentration of species i per unit volume

u is the wind velocity vector

D_{ij} is the molecular diffusivity

R_i is the rate of production of species i by chemical reaction

t is time

According to Mathis et al. the overbar indicates time-averaged quantities, unprimed quantities are mean values, and primed quantities are fluctuations from the means. The second and third quantities on the left side of the above equation represent the advective transport by the mean wind and diffusive transport due to the fluctuation in the wind, respectively. The first term on the right side of the equation is the transport by the molecular diffusion (which is generally four orders of magnitude less than the turbulent diffusion), and the second term represents the chemical production.

A8 THE COLSTRIP DIFFUSION STUDY

The Colstrip diffusion study was conducted under contract from MPC by the MSU meterological group. Personnel from the Montana Air Quality Bureau assisted in the study. The following brief summary of the study is extracted from the "Preliminary Results of the Colstrip Diffusion Study" by Heimbach and Super dated August 13, 1974.

The diffusion characteristics of the Colstrip region were assessed in the study by the aerial tracing of an ice nuclei plume released near the proposed plant site. The ice nuclei were emitted continuously at the top of a 300-foot tower located on a hill 200 feet above the plant base. The release height therefore corresponded to the stack top level of Units 1 and 2. The ice nuclei were generated by burning an $AgI\text{-}NH_4$ complex dissolved in acetone to produce AgI crystals about .03 μm in size. The resultant plume was traced by using an airborne NCAR ice nucleus counter to detect the edges of the plume. Vertical cross-sections of the plume were measured at various downwind distances by flying the aircraft through the plume at different levels. Usually two passes were made at each level. During the flights the location of the aircraft with respect to the plant site was noted using a system of ground check points.

During the final two weeks of field measurements the aircraft data was supplemented with ground level data measured using an NCAR counter similar to the airborne instrument. The ground-based counter was mounted on a jeep.

Ten successful days of airborne tracing were conducted during winter and twelve successful days were conducted during spring. A total of 651 plume penetrations were flown and processed.

A9 LONG-TERM MODEL EQUATIONS

The basic equation of the long-term model is

$$\overline{X} = \sum_{n} \sum_{SC} \sum_{W} F(D_n, SC, W) \cdot X(r_n, SC, W) \tag{A9-1}$$

where $\overline{X}$ is the long-term average concentration

D_n indicates the $22\frac{1}{2}^0$ wind sector in which the transport from a particular source (n) to the receptor occurs.

r_n is the downwind distance from the source (n) to the receptor.

$F(D_n,SC,W)$ is the relative frequency of occurrence of the wind direction Sector D_n, the stability class SC, and the wind speed class W.

$X(r_n,SC,W)$ is the concentration at the receptor which is the distance r_n from source (n) resulting from stability class SC and wind speed class W.

For conditions of unlimited mixing the concentration of the receptor X is given by:

$$X(r_n,SC,W) = \frac{2Q_n}{\sqrt{2\pi}\ \sigma_z(r_n,SC)u(W)\left(\frac{2\pi r_n}{16}\right)} \exp\left\{-\frac{1}{2}\left[\frac{H_{En}}{\sigma_z(r_n,SC)}\right]^2\right\} \tag{A9-2}$$

where $u(W)$ is the wind speed corresponding to wind speed class W.

H_{En} is the effective height of the plume from source (n).

$\sigma_z(r_n,SC)$ is the standard deviation of the vertical concentration distribution corresponding to downwind distance r_n and stability class SC.

Q_n is the emission rate from source (n).

When the mixing depth is not unlimited, but extends only to a height L, equation (2) is applied for downwind distances less than or equal to r_L where $\sigma_z(r_L,SC) = .47L$. For downwind distances greater than or equal to $2r_L$ the following equation is used.

$$X(r_n,SC,W) = \frac{Q_n}{L\ u(W)\left(\frac{2\pi r_n}{16}\right)} \qquad \text{(A9-3)}$$

Concentrations for distances between r_L and $2r_L$ are found by linear interpolation between $X(r_L,SC,W)$.

The effective plume height H_e was calculated using Briggs' (1969) equations for plume rise in an unstable or neutral atmosphere only, as the silver iodide tracing study conducted by MSU indicated that vertical dispersion coefficients predicted from the Pasquill stable classes do not ofter occur at Colstrip. The Briggs' equations are given in Appendix A11.

A10 SHORT-TERM MODEL EQUATIONS

The basic equations used in the short-term model are those given by Turner (1970). For unlimited mixing the ground level concentration X is given by

$$X = \sum_n \frac{Q_n}{\pi \sigma_y(r_n) \sigma_z(r_n) u} \quad \exp\left\{ -\frac{1}{2} \left[\left(\frac{H_{En}}{\sigma_z(r_n)} \right)^2 + \left(\frac{A_n}{\sigma_y(r_n)} \right)^2 \right] \right\} \tag{A10-1}$$

where Q_n is the emission rate of a given effluent from source (n)

$\sigma_y(r_n)$ is the standard deviation of the horizontal concentration distribution at downwind distance r_n

$\sigma_z(r_n)$ is the standard deviation of the vertical concentration distribution at downwind distance r_n

u is the mean wind speed

H_{En} is the effective height of the plume from source (n)

A_n is the cross wind distance from the source to the receptor

When a mixing depth of height L is present, ground level concentrations are given by equation (1) for distances less than or equal to r_L where r_L is determined by $\sigma_z(r_L)=.47L$. For downwind distances greater than or equal to $2r_L$ the concentration is given by

$$X = \frac{Q_n}{\sqrt{2\pi}\ \sigma_y(r_n) L u} \quad \exp\left\{ -\frac{1}{2} \left[\frac{An}{\sigma_y(r_n)} \right]^2 \right\} \tag{A10-2}$$

As was the case for the long-term model, Briggs' (1960) unstable or neutral plume rise equations were used to calculate H_{En}.

A11 METHOD OF EFFECTIVE PLUME HEIGHT CALCULATION

The effective height of the plumes emitted from Colstrip Units 1-4 stacks were calculated using the equations recommended by Briggs' (1969, p.58). "For fossil-fuel plants with a heat emission of 20 MW or more," the equations are:

(1) For neutral and unstable conditions

$$\Delta h = 1.6F^{\frac{1}{3}} u^{-1} x^{\frac{2}{3}} \qquad (x<10h_s) \qquad \text{(A11-1)}$$

$$\Delta h = 1.6F^{\frac{1}{3}} u^{-1} (10h_s)^{\frac{2}{3}} \qquad (x>10h_s) \qquad \text{(A11-2)}$$

(2) For stable conditions

$$s = \frac{g}{T_a} \frac{\partial\theta}{\partial Z} \qquad \text{(A11-3)}$$

$$\Delta h = 1.6F^{\frac{1}{3}} u^{-1} x^{\frac{2}{3}} \qquad (x<2.4us^{-\frac{1}{2}}) \qquad \text{(A11-4)}$$

$$\Delta h = 2.9\left(\frac{F}{us}\right)^{\frac{1}{3}} \qquad (x>2.4us^{-\frac{1}{2}}) \qquad \text{(A11-5)}$$

(3) For neutral, unstable, and stable conditions

$$F = g\, W_o\, R_o^{\,2} \left(\frac{T_p - T_a}{T_p}\right) \qquad \text{(A11-6)}$$

$$H_e = \Delta h + h_s \qquad \text{(A11-7)}$$

where Δh = plume rise in meters

F = initial plume buoyancy flux in $\frac{\text{meters}^4}{\text{seconds}^3}$

u = mean wind speed in meters per second

x = downwind distance in meters

h_s = physical stack height in meters

s = stability parameter in seconds^{-2}

T_a = ambient air temperature in degrees Kelvin

$\frac{\partial\theta}{\partial Z}$ = environmental lapse rate of potential temperature in degrees centigrade per meter

W_o = initial effluent vertical velocity in meters per second

R_o = stack top radius in meters

T_p = initial plume temperature in degrees Kelvin

H_E = effective plume height in meters

A12 METHOD OF COOLING TOWER EFFECTIVE PLUME HEIGHT CALCULATION

Cooling tower effective plume heights were calculated using two approaches: the "wet" approach assuming environmental relative humidities of 100%, and the "dry" approach assuming low environmental relative humidities.

For cooling tower "dry" case the equations of Briggs' (1969) were used:

For neutral and unstable conditions:

$$\Delta h = 1.6F^{\frac{1}{3}}u^{-1}x^{\frac{2}{3}} \qquad (x<x_1) \qquad \text{(A12-1)}$$

$$\Delta h = 1.6F^{\frac{1}{3}}u^{-1}x_1^{\frac{2}{3}}\left[.4 + .64\left(\frac{x}{x_1}\right) + 2.2\left(\frac{x}{x_1}\right)^2\right]\left[1 + .8\left(\frac{x}{x_1}\right)\right]^{-2} \qquad (x_1<x<3x_1) \qquad \text{(A12-2)}$$

$$\text{where} \quad x_1 = 2.16F^{\frac{2}{5}}h_s^{\frac{3}{5}} \qquad \text{(A12-3)}$$

For $x>3x_1$ Δh is assumed to be the constant value given by $\Delta h(3x_1)$ calculated in equation A12-2.

The equations used for stable conditions are the same as those used for the stack plume.

For the cooling tower "wet" case Hanna's equation for the initial buoyancy flux F was used:

$$F = g\, W_o\, R_o^2\left[\frac{T_{vp}-T_{va}}{T_{vp}} + (q_{po}-q_{eo})\frac{L}{C_pT_p}\right] \qquad \text{(A12-4)}$$

In the calculations the mixing ratio (m) was used in place of the specific humidity (q) as they are nearly equal (Hess 1959)[1].

---

1. Since both the environment and the plume were assumed initially saturated in the calculations only saturation mixing ratios were used.

The mixing ratios and virtual temperatures were determined from the following equations:

$$m_s = .622 \frac{e_s}{p-e_s} \qquad \text{(Hess 1959)} \qquad \text{(A12-10)}$$

$$e_s = \text{antilog}_{10}\left[9.28603523-2322.37885/T\right]$$

$$\text{(Tabata 1973)} \qquad \text{(A12-11)}$$

$$T_v = T(1 + .61m) \qquad \text{(Hess 1959)} \qquad \text{(A12-12)}$$

where e_s = saturated water vapor pressure.

p = 898mb, the standard pressure at 3300 ft. (Haltimer et al. 1957), the approximate elevation at the top of the cooling tower.

The equations for the plume rise, Δh, and the effective plume height, H_E, used for the "wet" cooling tower are the same as those used for the dry case, except for the different initial buoyancy flux.

Because mechanical draft cooling tower plumes are initially multicelled or multi-ported, the question exists when trying to model the plume rise whether to use the initial buoyancy flux for a single cell or for all of the cells combined. Meyer et al. have determined that when using the bent-over formulations of Briggs' and Hanna, the plume trajectory from a seven-port tower was best predicted using the F_O value for one cell. This approach was followed in these calculations.

Table 11-8 contains the results of the plume height calculations.

A13 VISUAL RANGE CALCULATION

According to the "Air Quality Criteria for Sulfur Oxides" (1970), visual range L_v is given by:

$$(1) \quad L_v = \frac{2.4 \times 10^{-3}}{\Sigma N_{ij} A_{ij} E_{ij}} \qquad \text{(A13-1)}$$

where: L_v is in miles, with a contrast threshold of 0.02.

i and j identify a class of particulates of a given diameter (d) and refractive index (n), respectively.

N_{ij} represents the number of ij particles per unit volume.

A_{ij} represents the cross-sectional area of an ij particle.

E_{ij} is the scattering ratio of the ij particle.[1]

For 90% relative humidity the equation was written as suggested in the Air Quality document:

$$(2) \quad L_v = \frac{2.4 \times 10^{-3}}{(TSP \mu g/m^3)\,(.33 \times 10^{-5}) + (H_2SO_4 \mu g/m^3)\,(.69 \times 10^{-5})}$$

(A13-2)

where: $TSP \mu g/m^3$ is the total mass concentration of suspended particulate in micrograms per cubic meter.

$H_2SO_4 \mu g/m^3$ is the sulfuric acid concentration in micrograms per cubic meter.

---

1. According to HEW 1970 "The particle scattering ratio, E, is the ratio of the area of the wave front acted on by the particles to the geometric area of the particle. This ratio depends on the particle's refractive index, its shape, and its size relative to the wavelength of light" (p.10).

The sulfuric acid concentration was determined as a function of SO_2 concentration and relative humidity from Figure 1-4 of the "Air Quality Criteria for Sulfur Oxides." The assumed average background and plant-contributed 24-hour concentrations of SO_2 and total suspended particulates used were:

TABLE 1

SO_2		Suspended Particulates	
background	plant	background	plant
-	(24 hour) 260 $\mu g/m^3$	10 $\mu g/m^3$	(24 hour) 10 $\mu g/m^3$

Inserting the values in Table 1 into equation 2 resulted in:

Background: L_V = 73 miles.

Background plus plant contribution: L_V = 12 miles (84% reduction from background)

Plant contribution only = L_V = 14 miles (an 81% reduction from background)

A-14: COLSTRIP TEMPERATURE-HUMIDITY DATA

Temperature °C	Time at Indicated Conditions, hr — Humidity, %					
	65 to 75	75 to 84	85 to 94	95	96 to 99	100
-27 -24	45	18	0	0	0	0
-23 -21	33	20	3	0	0	0
-20 -16	63	59	47	0	0	0
-15 -13	39	65	46	0	0	0
-12 - 7	89	131	128	3	4	0
- 6 - 2	98	136	237	11	29	2
- 1 1	75	83	144	8	33	1
2 4	44	63	129	2	9	0
5 9	102	136	146	2	0	0
10 15	52	107	86	0	0	0
18 24	59	36	18	0	0	0
Total Hours	699	854	984	26	75	3

Source: Westinghouse, 1973.

APPENDIX B: Hydrology

B1 Montana Water Quality Standards and Regulations

Montana has a number of standards and regulations that form the basis for a broad comprehensive water pollution control program administered by the Water Quality Bureau of the Environmental Sciences Division. Important elements of the state program are:

1. Water quality standards.

2. State and federal waste discharge permits.

3. State-wide monitoring and surveillance programs.

4. Facilities construction grants, plan review, operation and maintenance inspections, and traning and licensing of operators.

Water quality standards and criteria have been established by the state of Montana for both interstate and intrastate waters. The latest revision of these standards was completed in July, 1973. The new standards became effective in November, 1973. Montana water quality standards serve as a functional tool in protecting water quality. There are also a number of laws, statutes, and regulations which complement the water quality standards and significantly assist in protecting water quality.

As part of the water quality standards, all surface waters in Montana have been classified with respect to water use. The primary distinction in use of study area surface waters is variation in the growth and propagation of salmonid and non-salmonid fishes. The portions of the classifications applicable to the study area are listed below, quoting from Montana's Water Quality Standards (MAC 16-2.14(10)-S14480).

B-D1 classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and

food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters, nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters, nor are 20 percent of the samples to exceed 1,000 coliforms per 100 mililiters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 5 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 1^0F maximum increase above naturally occurring water temperature is allowed within the range of 32^0F to 66^0F; within the naturally occurring range of 66^0F to 66.5^0F, no discharge is allowed which will cause the water temperature to exceed 67^0F; and where the naturally occurring water temperature is 66.5^0F or greater, the maximum allowable increase in water temperature is 0.5^0F. A 2^0F per hour maximum decrease below naturally occurring water temperature is allowed within the range of 55^0F to 32^0F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U.S. Public Health Service Drinking Water Standards or subsequent editions; no increase of more than 10 percent of the concentration present in the receiving water is permitted; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

B-D$_2$ classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary, and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities; bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality critera.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter from October 1 through June 1 nor below 6.0 milligrams per liter from June 2 through September 30.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained

without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 1^{0}F maximum increase above naturally occurring water temperature is allowed within the range of 32^{0}F to 66^{0}F; within the naturally occurring range of 66^{0}F to 66.5^{0}F, no discharge is allowed which will cause the water temperature to exceed 67^{0}F; and where the naturally occurring water temperature is 66.5^{0}F or greater, the maximum allowable increase in water temperature is 0.5^{0}F. A 2^{0}F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55^{0}F, and a 2^{0}F maximum decrease below naturally occurring water temperature is allowed within the range of 55^{0}F to 32^{0}F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U.S. Public Health Service Drinking Water Standards or subsequent editions, and no increase of more

than 10 percent of the concentration present in the receiving water is permitted; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

B-D_3 classification

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 mililiters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 5.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 shall be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 3°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 77°F; within the naturally occurring range of 77°F to 79.5°F, no thermal discharge is allowed which will cause the water temperature to exceed 80°F; and where the naturally occurring water temperature is 79.5 F° or greater, the maximum allowable increase in water temperature is 0.5°F. A 2°F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55°F, and a 2°F maximum decrease below naturally occurring water temperature is allowed within the range of 55°F to 32°F.

This applies to all waters in the state classified B-D3 except from the Billings water supply intake to the water diversion at Intake, a 3°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 79°F; within the range of 79 F° to 81.5°F, no thermal discharge is allowed which will cause the water temperature to exceed 82°F;

and where the naturally occurring water temperature is 81.5^{0}F or greater, the maximum allowable increase in water temperature is 0.5^{0}F.

From the water diversion at Intake to the North Dakota state line, a 3^{0}F maximum increase above naturally occurring water temperature is allowed within the range of 32^{0}F to 82^{0}F; within the range of 82^{0}F 84.5^{0}F, no thermal discharge is allowed which will cause the water temperature to exceed 85^{0}F; and where the naturally occurring water temperature is 84.5^{0}F or greater, the maximum allowable increase in water temperature is 0.5^{0}F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U.S. Public Health Service Drinking Water Standards or subsequent editions, and no increase of more than 10 percent of the concentration present in the receiving water is permitted; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

TABLE 1

WATER-USE CLASSIFICATIONS OF STUDY AREA SURFACE WATERS

Yellowstone River drainage from the Billings water supply intake to the North Dakota state line except the tributaries listed below.	B-D_3
Pryor Creek drainage.	B-D_1
Big Horn drainage above but excluding William's Coulee near Hardin.	B-D_1
Big Horn drainage from and including William's Coulee to the Yellowstone River except the Little Big Horn listed below.	B-D_2
Little Big Horn drainage above and including Lodgegrass Creek near Lodge Grass.	B-D_1
Remainder of the Little Big Horn drainage.	B-D_2
Tongue River (mainstem) from Tongue River Reservoir to but excluding Prairie Dog Creek	B-D_2
Remainder of the Tongue River drainage.	B-D_3
Fox Creek drainage near Sidney.	B-D_2
Little Missouri and Belle Fourche drainage—all waters.	B-D_3

In addition to the specific water quality criteria, there are a number of general water quality criteria that are part of the Montana water quality standards.

The Federal Water Pollution Control Act Amendments of 1972 established a national permit system. Industrial, municipal, and other point source discharges are required to obtain permits to discharge pollutants into streams. The EPA (U.S. Environmental Protection Agency) has given states the authoritty to administer the permit program, providing the states conform to certain guidelines. In June, 1974, Montana assumed most of the federal permit program. The permit program provides that not later than July 1, 1977, effluent limitations for point sources, other than publicly owned treatment works, shall require the application of best practicable control technology. For publicly owned treatment works, secondary treatment of wastes will be required by July 1, 1977.

Montana has a state-wide monitoring and surveillance program, which includes periodic compliance monitoring of municipal and industrial wastes, long-term baseline monitoring of streams, and a state-wide program for determining the general quality of all significant surface waters. This program identifies areas with water quality problems and provides basic data for water quality management and planning programs.

B2: <u>Hydrology and Water Quality Sampling Sites</u>.

SYSTEM FOR GEOGRAPHIC LOCATION OF FEATURES

Wells, springs, water-sampling locations, and stream-gaging locations are assigned numbers based on the system of land subdivision used by the U. S. Bureau of Land Management. The number consists of twelve characters and describes the location by township, range, section, and position within the section. The figure below illustrates the numbering method. The first three characters of the number give the township, the next three characters the range. The next two numbers give the section number within the township, and the next three letters describe the location within the quarter section (160-acre tract) and the quarter-quarter section (40-acre tract), and the quarter-quarter-quarter section (10-acre tract). These subdivisions of the 640-acre section are designated a, b, c, and d in a counterclockwise direction, beginning in the northeast quadrant. If there is more than one feature in a 10-acre tract, consecutive digits beginning with 2 are added to the number. For example, if a water-quality sample was collected in sec.21, T.9N., R20W, it would be numbered 09N20W210AA2. The letters DAA indicate that the well is in the NE¼ of the NE¼ of the SE¼, and the number 2 following the letters DAA indicates there is more than one water-quality sampling location in this 10-acre tract.

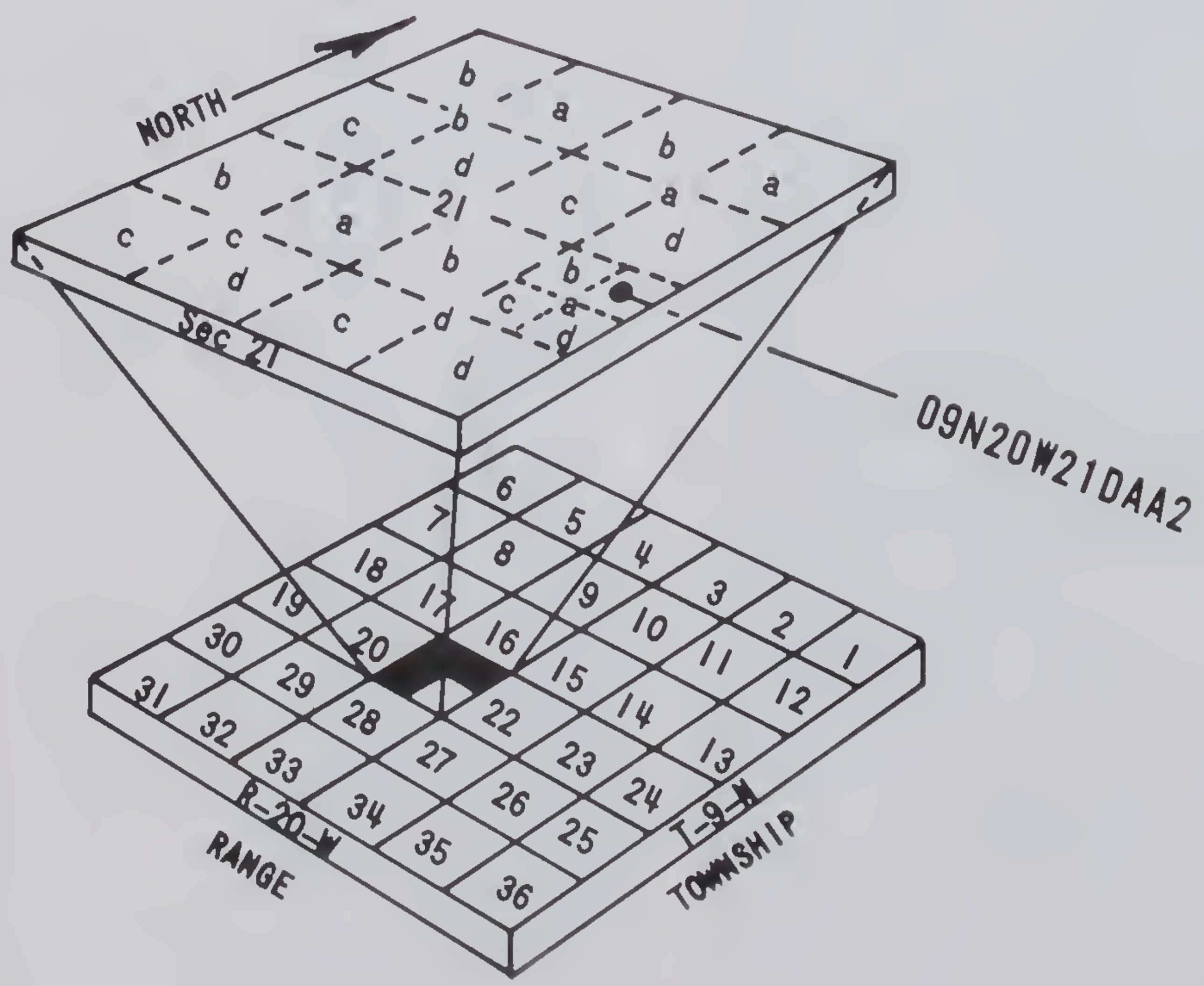


FIGURE 1

TABLE 1

GAGING STATIONS IN THE STUDY AREA

STREAM AND SITE	CURRENT STATUS	COUNTY	LOCATION
Bighorn River at Bighorn	Operational	Treasure	05N 34E 33AA
Bighorn River near St. Xavier	Operational	Big Horn	06S 31E 16BA
Beauvais Creek near St. Xavier(1)	Operational	Big Horn	04S 30E 15BC
Rotten Grass Creek near St. Xavier	Discontinued	Big Horn	05S 33E 07A
Soap Creek near St. Xavier(1)	Discontinued	Big Horn	06S 32E 10A
Little Bighorn River near Hardin	Operational	Big Horn	01S 34E 19AA
Little Bighorn River below Pass Creek near Wyola	Operational	Big Horn	07S 35E 35 ACC
Little Bighorn River at state line near Wyola(1)	Operational	Big Horn	09S 33E 36CB
Lodge Grass Creek above Willow Creek diversion near Wyola	Operational	Big Horn	08S 34E 19BB
Powder River at Moorhead	Discontinued	Powder River	09S 48E 08B
Powder River near Locate(1)	Operational	Custer	08N 51E 14BC
Little Powder River near Broadus(1)	Discontinued	Powder River	05S 52E 21BA
Rosebud Creek near Forsyth(2)	Discontinued(2)	Rosebud	05N 42E 09C
Sarpy Creek near Hysham	Recent(3)	Treasure	--- --- --
Armells Creek near Forsyth	Recent(3)	Rosebud	--- --- --
Tongue River at state line near Decker	Operational	Big Horn	09S 40E 33BA
Tongue River at dam near Decker	Operational	Big Horn	08S 40E 13A
Tongue River below Hanging Woman Creek near Birney	Recent(3)	Rosebud	--- --- --
Tongue River near Ashland	Operational	Rosebud	01S 44E 02BD

STREAM AND SITE	CURRENT STATUS	COUNTY	LOCATION
Tongue River at Brandenburg Bridge	Recent(3)	Rosebud	--- --- --
Tongue River at Miles City	Operational	Custer	07N 47E 23D
Hanging Woman Creek near Birney	Recent(3)	Rosebud	--- --- --
Otter Creek at Ashland	Recent(3)	Rosebud	--- --- --
Pumpkin Creek near Miles City	Recent(3)	Custer	--- --- --
Yellowstone River at Billings(1)	Operational	Yellowstone	01N 26E 34AA
Yellowstone River at Myers	Recent(4)	Treasure	06N 35E 21
Yellowstone River at Forsyth	Recent(3)	Rosebud	--- --- --
Yellowstone River at Miles City	Operational	Custer	08N 47E 28BC
Yellowstone River near Terry	Recent(3)	Prairie	--- --- --
Yellowstone River near Sidney(1)	Operational	Richland	22N 59E 09CAC

(1) Site peripheral to the study area.
(2) Past site discontinued as of 1953; two new sites will be established on this creek before October, 1974.
(3) Established since 1972
(4) Established since 1972 but partial records available from previous years.

TABLE 2

Summary of the major Water Quality Bureau sampling sites established in the defined study area.

STREAM AND SITE	COUNTY	SUB-BASIN DESIGNATION	LOCATION
Bighorn River near Bighorn	Treasure	43P	05N 34E 34BC
Bighorn River south of Hardin	Big Horn	43P	02S 33E 21BC
Rotten Grass Creek at St. Xavier	Big Horn	43P	04S 32E 26AB
Little Bighorn River north of Wyola	Big Horn	430	07S 35E 35AC
Little Bighorn River near Hardin	Big Horn	430	01S 34E 20BB
Lodge Grass Creek at Lodge Grass	Big Horn	430	06S 35E 13DA
Owl Creek near Lodge Grass	Big Horn	430	06S 36E 19AA
Tullock Creek east of Hardin	Big Horn	43P	01N 35E 36DD
Tullock Creek near Bighorn	Treasure	43P	04N 34E 02AC
Froze-to-Death Creek north of Hysham[1]	Treasure	42KJ	07N 36E 26AA
Great Porcupine Creek near Vananda[1]	Rosebud	42KJ	07N 38E 13AA
Little Porcupine Creek north of Forsyth[1]	Rosebud	42KJ	06N 41E 03AC
Sunday Creek north of Miles City[1]	Custer	42K	08N 47E 03CC
Reservation Creek east of Saunders[1]	Rosebud	42KJ	06N 38E 34CB
Sarpy Creek below Westmoreland[1]	Big Horn	42KJ	01N 36E 15BC
Sarpy Creek east of Hysham[1]	Treasure	42KJ	06N 36E 18AB
Sweeney Creek east of Rosebud[1]	Rosebud	42KJ	06N 43E 22AD
Moon Creek southwest of Miles City[1]	Custer	42KJ	07N 46E 30DA
O'Fallon Creek near Fallon	Prairie	42L	12N 52E 03DA
Armells Creek west of Forsyth[1]	Rosebud	42KJ	06N 39E 23AC
Armells Creek at Highway 315[1]	Rosebud	42KJ	05N 39E 36BB
West Fork of Armells Creek near Highway 315	Rosebud	42KJ	04N 40E 16AB

STREAM AND SITE	COUNTY	SUB-BASIN DESIGNATION	LOCATION
Upper West Fork of Armells Creek(1)	Rosebud	42KJ	03N 39E 26AC
East Fork of Armells Creek at Highway 315(1)	Rosebud	42KJ	04N 40E 22CA
East Fork of Armells Creek north of Colstrip(1)	Rosebud	42KJ	04N 40E 22CA
East Fork of Armells Creek at Colstrip(1)	Rosebud	42KJ	01N 41E 03BB
Yellowstone River near Custer	Yellowstone	43Q	05N 33E 35DA
Yellowstone River near Myers	Treasure	42KJ	06N 35E 21DC
Yellowstone River at Forsyth	Rosebud	42KJ	06N 40E 22AA
Yellowstone River near Rosebud	Rosebud	42KJ	06N 42E 15BC
Yellowstone River at Miles City	Custer	42K	08N 47E 28BC
Yellowstone River near Fallon	Prairie	42M	13N 52E 27AC
Rosebud Creek south of Kirby(1)	Big Horn	42A	06S 39E 29BA
Rosebud Creek at Busby(1)	Big Horn	42A	04S 39E 06AB
Rosebud Creek south of Colstrip	Rosebud	42A	01S 42E 08AC
Rosebud Creek east of Colstrip	Rosebud	42A	03N 43E 05DC
Rosebud Creek south of Rosebud	Rosebud	42A	05N 42E 08DC
Rosebud Creek near Rosebud	Rosebud	42A	06N 42E 16DC
Lame Deer Creek at Lame Deer(1)	Rosebud	42A	02S 41E 33AD
Lame Deer Creek below Lame Deer(1)	Rosebud	42A	02S 41E 28DB
Davis Creek southwest of Busby(1)	Big Horn	42A	04S 82E 11DA
Tongue River in Wyoming above Decker	Sheridan	42B	57N 84W (Wyo.)
Tongue River in Montana near Decker	Big Horn	42B	09S 40E 22DA
Tongue River southwest of Birney	Rosebud	42B	06S 42E 32CC
Tongue River near Ashland	Rosebud	42C	03S 44E 10BD
Tongue River near Brandenburg	Rosebud	42C	01N 44E 14AC
Tongue River near Garland	Custer	42C	03N 47E 06BD
Tongue River near Miles City	Custer	42C	07N 47E 04DD
Hanging Woman Creek west of Quietus	Big Horn	42B	08S 43E 17DD

STREAM AND SITE	COUNTY	SUB-BASIN DESIGNATION	LOCATION
Hanging Woman Creek near Birney	Rosebud	42B	06S 43E 18BB
Otter Creek near Otter	Powder River	42C	06S 46E 19CD
Otter Creek near Ashland	Rosebud	42C	03S 44E 11DA
Pumpkin Creek at Highway 313 East of Ashland (1)	Powder River	42C	03S 48E 29DD
Pumpkin Creek near Volborg (1)	Custer	42C	01N 49E 05DB
Pumpkin Creek at Highway 312 south of Miles City (1)	Custer	42C	06N 48E 35CB
Little Pumpkin Creek southwest of Volborg (1)	Powder River	42C	01S 49E 06BD
Powder River near Moorhead	Powder River	42J	08S 48E 28CB
Powder River near Broadus	Powder River	42J	05S 51E 03AD
Powder River near Powderville	Powder River	42J	01S 54E 17CA
Powder River near Locate	Custer	42J	08N 51E 23CD
Powder River southwest of Terry	Prairie	42J	11N 50E 03DC
Little Powder River southeast of Broadus	Powder River	42I	05S 52E 28AA
Mizpah Creek east of Volborg (1)	Custer	42J	02N 51E 09CD
Mizpah Creek near Mizpah	Custer	42J	06N 51E 24BD

(1) Intermittent streams

TABLE 3

Miscellaneous sites sampled by the Water Quality Bureau through the period of study.

STREAM AND SITE	COUNTY	SUB-BASIN DESIGNATION	LOCATION	TRIBUTARY OF
Bighorn River near Hardin	Big Horn	43P	01S 34E 19BA	Yellowstone River
Soap Creek southwest of St. Xavier	Big Horn	43P	05S 32E 29AB	Bighorn River
Little Bighorn River at state line	Big Horn	430	09S 33E 36CB	Bighorn River
Pass Creek near Wyola	Big Horn	430	08S 35E 22BD	Little Bighorn River
Middle Little Bighorn River south of Crow Agency	Big Horn	430	04S 35E 09DD	Bighorn River
Reno Creek southest of Crow Agency	Big Horn	430	04S 36E 17AC	Little Bighorn River
Upper Owl Creek southeast of Lodge Grass	Big Horn	430	07S 36E 34AA	Little Bighorn River
East Owl Creek southeast of Lodge Grass	Big Horn	430	07S 36E 11BC	Owl Creek
Sioux Pass Creek southeast of Lodge Grass	Big Horn	430	07S 36E 03BC	Owl Creek
Grey Blanket Creek south-east of Lodge Grass	Big Horn	430	06S 36E 19AA	Little Bighorn River
Alf Creek north of Sanders(1)	Treasure	42KJ	07N 36E 22DC	Yellowstone River
Starved-to-Death Creek north of Sanders (1)	Treasure	42KJ	07N 37E 26AC	Yellowstone River
Smith Creek near Forsyth(1)	Rosebud	42KJ	06N 40E 28AA	Yellowstone River

STREAM AND SITE	COUNTY	SUB-BASIN DESIGNATION	LOCATION	TRIBUTARY OF
Armells Creek near Highway 315	Rosebud	42KJ	05N 39E 14BA	Yellowstone River
Sheep Creek at Highway 315(1)	Rosebud	42KJ	04N 40E 22BB	Armells Creek
Yellowstone River at Huntley	Yellowstone	43_Q	07N 27E 24CA	-----
West Rosebud Creek south of Forsyth(1)	Rosebud	42A	05N 41E 28DA	Rosebud Creek
Muddy Creek northeast of Busby	Big Horn	42A	02S 40E 35CB	Rosebud Creek
Indian Creek south of Kirby	Big Horn	42A	06S 39E 31CA	Rosebud Creek
Tongue River at Birney Village	Rosebud	42C	05S 43E 08CC	Yellowstone River
Youngs Creek south of Decker in Wyoming	Sheridan	42B	57N 84W (WY)	Tongue River
Squirrel Creek at Decker	Big Horn	42B	09S 40E 29CA	Tongue River
Deer Creek northeast of Decker (1)	Big Horn	42B	09S 41E 10CC	Tongue River
Tongue River Irrigation Reservoir	Big Horn	42B	08S 40E 25BB	Tongue River
Logging Creek south of Ashland (1)	Rosebud	42C	03S 44E 28AB	Tongue River
Stroud Creek west of Otter (1)	Big Horn	42B	08S 43E 02AB	Hanging Woman Creek
Cow Creek near Fort Howe (1)	Powder River	42C	06S 46E 30BC	Otter Creek
Powder River near Mizpah	Custer	42J	06N 52E 30DB	Yellowstone River
Mizpah Creek near Olive (1)	Powder River	42J	03S 50E 26CC	Powder River

STREAM AND SITE	COUNTY	SUB-BASIN DESIGNATION	LOCATION	TRIBUTARY OF
Sand Creek east of Volborg(1)	Custer	42J	02N 51E 08BB	Mizpah Creek
O'Fallon Creek near Ismay	Fallon	42L	08N 56E 30DA	Yellowstone River

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(1) Intermittent streams.

TABLE 4

U.S. GEOLOGICAL SURVEY WATER QUALITY STATION IN THE STUDY AREA

STREAM AND SITE	CURRENT STATUS	COUNTY	LOCATION
Beauvais near St. Xavier(1)	Operational	Big Horn	04S 30E 15
Bighorn River at Bighorn	Operational	Treasure	05N 34E 33
Bighorn River near Hardin(2)	Discontinued	Big Horn	01S 33E 24
Bighorn River at Kane, WY (1)	Operational	Big Horn	55N 94W 09
Bighorn River near St. Xavier	Operational	Big Horn	06S 31E 16
Little Bighorn River near Hardin	Operational	Big Horn	01S 34E 19
Little Bighorn River below Pass Creek near Wyola	Operational	Big Horn	07S 35E 35
Powder River at Moorhead	Discontinued	Powder River	09S 48E 08
Tongue River at Miles City	Operational	Custer	07N 47E 23
Tongue River below Hanging Woman Creek near Birney	Recent (3)	Rosebud	--- --- --
Tongue River at Brandenburg Bridge	Recent (3)	Rosebud	--- --- --
Tongue River at state line near Decker	Operational	Big Horn	09S 40E 33
Yellowstone River near Laurel (1, 2)	Operational	Yellowstone	02S 25E 04
Yellowstone River at Billings (1)	Operational	Yellowstone	01N 26E 34
Yellowstone River at Huntley (1, 2)	Operational	Yellowstone	02N 27E 24
Yellowstone River at Custer (2)	Discontinued	Yellowstone	05N 33E 35
Yellowstone River at Myers	Recent (3)	Treasure	--- --- --
Yellowstone River at Forsyth	Recent (3)	Rosebud	--- --- --
Yellowstone River near Miles City	Operational	Custer	08N 47E 31
Yellowstone River near Terry	Recent (3)	Prairie	--- --- --
Yellowstone River near Sidney (1)	Operational	Richland	22N 59E 09

(1) Site not within the boundaries of the study area.
(2) Water quality data only (i.e., no discharge measurements available).
(3) Site established since 1972.

APPENDIX C: Soils

C1 Explanation to the General Soils Map

The "General Soils" map covers the area from 45° long. to 47° long. and 105° lat. to 108° lat. Soil association maps (1:500,000 scale) constructed and published by the Soil Conservation Service were used to draft the soil associations that appear on the map. The associations were grouped according to type of physiography as described in Section 10.1.5. (Mountains, Foothills, etc). Detailed descriptions of soil associations that appear in the study area are presented on the following pages. Dominant soil series (the level of soil classification of which detailed impact interpretations are made) are listed for each association in which they appear. Impact parameters (percentage of coarse fragments, depth to bedrock, pH fertility, shrink/swell, and tilth) are listed for each series when data is available. Impact interpretations, such as compacted soil erosion hazard, and suitability ratings for foundations, access roads, and rights-of-way, also are shown for each association.

This soils inventory presented on the map used USGS Area Maps (AMS 1954) with 1:250,000 scale as a base since this was the only map series with topographical information available for the entire study area.

As noted previously, the study area was divided into broad physiographic units, with each unit defined by relief, elevation, geologic structure, and geomorphic process. These units were then subdivided, using the same criteria, and the additional criteria of climatic and soil properties. Data extrapolation to areas of the same mapping unit was necessary when detailed soils data were not available.

GENERAL SOILS
SOIL ASSOCIATIONS

- 1 Soils of the Mountains
- 1 Soils of the Foothills
- 1-6 Soils of the Plains
- 1 Soils of the Alluvial Lands

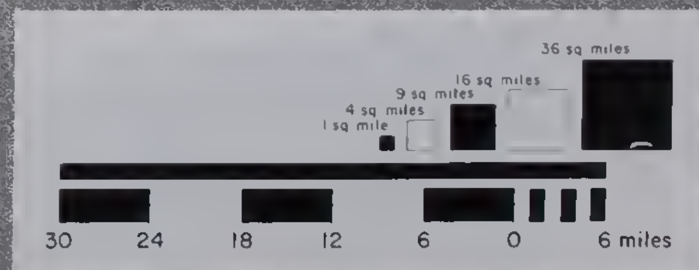
A) The four colors on the map indicate four groupings of soil associations according to physiography (mountains, foothills, plains, and alluvial).

B) The four groupings have been subdivided as described in Section 11.1.5., which covers general soils descriptions. The subdivisions are indicated by the first number in each mapping unit

C) The second number in each mapping unit indicates individual soil associations, described in detail in Appendix C1.

D) The entire hyphenated number indicates a specific soil association in a specific subdivision, and is used in connection with that association throughout this impact statement. The table included in Appendix C1 lists all associations that appear on this map and their numbers.

SOURCE USFS, SCS



Data Sources

Climatic data for the map came from the Average Annual Precipitation Map, 1953-1967 base period (SCS 1974) (see Section 10.1.1.). Geologic information was furnished by the Geologic Map of Montana (Ross, Andrews and Witking 1958) 1:500,000 scale.

Soil surveys listed as follows also provided information:

Published Surveys:

Yellowstone County (SCS 1972)
Powder River County (SCS 1972)
Treasure County (SCS 1972)
Beartooth RC&D (SCS 1970)

General Surveys:

Eastern Montana (Ashley and Mogan 1973)
Soils Series of the United States, Puerto Rico, and the Virgin Islands (SCS 1972)

The various conservation district offices of the SCS supplied additional detailed data where available.

Information was obtained from Planning Unit Descriptions in U.S. Forest Service headquarters of each national forest inventoried; much of the study area was examined on black and white aerial photographs, 1:60,000 scale, for checking of soils and physiography information (USFS 1971).

Table Symbols

The following list explains the symbols and abbreviations used with the soils data:

Soil Taxonomy:

mont.--montmorillonitic
calc.--calcareous

Impact Parameters:

H--high M--medium L--low
n.g.--native grassland
n.r.--native rangeland
r--rangeland
cult--cultivated
past--pasture

Impact Interpretations:

Erosion Hazard Categories
S--severe
M--moderate
SL--slight

Suitability Rating Categories:

G--good
F--fair
P--poor

TABLE 1

Soil Taxonomy					Impact Parameters					Impact Interpretations: Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
Soils of the Mountains # 1													
1-6	Duncom	Lithic Cryoboroll	loamy, mixed			No Data Available	8.0-8.4	L	R	M	F	F	F
	Tarrete	Vertic Cryoboroll	very-fine, mixed	Big Horn			7.6-8.6		n.g.				
	Mayflower	Argic Pachic Cryoboroll	fine, mont.										
Soils of the Foothills # 1													
1-	Lap	Lithic Calciboroll	loamy-skeletal, carbonatic		50-70	10-20	7.4-9.0		R				
	Armington	Vertic Haploboroll	very-fine, mixed	Big Horn		30-60	7.4-8.0	L	n.g.	M	F	F	G
	Reeder	Typic Argiboroll	fine-loamy, mixed			30-40	7.6-8.3		cult.				
Soils of the Plains # 1 - 6													
1-23	Farnuf	Typic Argiboroll	fine-loamy, mixed	Prairie			7.4-8.5		n.g.	M	G	G	G
	Shambo	Typic Haploboroll	fine-loamy, mixed				7.6-8.6		n.g.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/ Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
Soils of the Plains # 1 - 6 cont.													
1-24	Turner	Typic Argiboroll	fine-loamy, mixed	Dawson			7.4-8.0		Cult.	M	G	G	G
	Beaverton	Typic Argiboroll	loamy-skeletal, mixed			20-30	6.5-8.5	L	Cult.				
1-25	Tinsley	Typic Ustorthent	sandy-skeletal, mixed, fri.	Prairie	30-60		7.5-8.2		n.r.	M	G	G	G
	Lambert	Typic Ustorthent	fine-silty, mixed, calc.			>60	7.9-9.0	H	Cult.				
1-26	Norbert	Typic Ustorthent	clayey, mont., calc., frigid, shallow	Prairie		4-20	8.3-8.8		n.g.	M	G	G	G
	Vanda	Ustic Torriorthent	fine, mont., calc., mesic			>60	8.0-9.2	H					
1-27	Lambeth	Ustic Torriorthent	fine-silty, mixed, calc., frigid	Custer and Rosebud			8.0-8.4		n.g.	M	G	G	G
	Brandenberg	Lithic Ustorthent	loamy-skeletal, mixed, calcareous, frigid		10-35	10-20	7.2-8.6		n.g.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
Soils of the Plains #1 - 6 cont.													
1-22	Series not Identified			Rosebud		No Data Available							
1-20	Vanda	Ustic Torriorthent	fine, mont., calc., mesic	Rosebud		>60	8.0-9.2	H		M	G	G	G
	Lisam	Ustic Torriorthent	clayey, mont., nonacid, frigid			10-20	7.0-8.4		n.g.				
1-28	Keiser	Ustollic Haplargid	fine, silty, mixed, mesic	Big Horn		>60	6.6-8.5	M	n.g.				
	Hydro	Glossic Ustollic Natargids	fine, mont., mesic			>60	7.4-9.0	M-H	n.g.	M	G	G	G
	Gilt Edge	Haplustollic Natargid	fine, mont., mesic			>60	6.6-9.0	M-H	n.g.				
1-10	Cushman	Ustollic Haplargid	fine-loamy, mixed, mesic	Yellowstone		20-40	6.6-8.4	M	n.g.	M	G	G	G
	Baineville	Ustic Torriorthent	fine-silty, mixed, mesic, calc.			20-40	7.9-9.0	L					

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/ Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
Soils of the Plains # 1 - 6 cont.													
1-21	Terry	Ustollic Haplargid	coarse-loamy, mixed, mesic	Rosebud	0-15	20-40	7.0-8.4	L	n.g.	M	G	G	G
	Olny	Ustollic Haplargid	fine-loamy, mixed, mesic		0-15		7.2-8.2		R.				
1-9	Scroggim	Ustic Torriorthent	fine-silty, mixed, calc, frigid	Musselshell		24-30	8.4-8.9		n.g.	M	G	G	G
	Lone Pine	Borollic Camborthid	fine-silty, mixed				7.0-8.8		past.				

TABLE 1

Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Soils of the Plains - #2													
2-32	Ringling	Typic Haploboroll	Fragmental, mixed		30-80	5-20	7.4-8.4	L	n.g.				
	Fergus	Typic Argiboroll	fine, mixed	Rosebud		>60	6.6-8.4	M	cult.	S	G	F	G
	Relan	Typic Haploboroll	coarse-loamy, mixed		15-30	>60	7.4-8.8	L	n.g.				
2-33	Ringling	Typic Haploboroll	fragmental, mixed		30-80	5-20	7.4-8.4	L	n.g.				
	Cabba	Typic Ustorthent	loamy, mixed, calc., frigid	Powder River		<20	7.9-8.4	L	n.g.	S	G	F	G
	Yawdim	Ustic Torriorthent	clayey, mixed calc., shallow			4-20	8.0-8.4		n.g.				
2-34	Wayden	Typic Ustorthent	clayey, mont., calc., frigid, shallow	Big Horn		10-20	7.2-8.2		n.g.				
	Xavier	Typic Argiboroll	fine-silty, mixed						n.g.	S	G	F	G

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/ Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
Soils of the Plains - #2 cont.													
2-35	Lambert	Typic Ustorthent	fine-silty, mixed, calc.	Prairie		> 60	7.9-8.4	L	n.g.	S	G	F	G
	Dimyaw	Typic Ustorthent	fine, mont., calc., mesic				7.8-8.4		n.g.				
2-36	Cabba	Typic Ustorthent	loamy, mixed, calc., frigid	Powder River	0-5	< 20	7.9-8.4	L	n.g.	S	G	F	G
	Shingle	Typic Torriorthent	loamy, mixed, calc., mesic, shallow			10-20	8.0-8.2		r.				
	Wayden	Typic Ustorthent	clayey, mont., calc., frigid, shallow			10-20	7.2-8.2		n.g.				
	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow			10-20	7.9-8.4	H	n.g.				
2-37	Boxwell	Aridic Haploboroll	fine-loamy, mixed	Custer			7.0-8.5		cult.	S	G	F	G
	Attewan	Aridic Argiboroll	fine-loamy over sandy skeletal, mixed			20-40	6.8-8.4						
	Dast	Typic Ustorthent	coarse-loamy, mixed, calc., frigid			20-40	7.6-8.5		n.g.				

TABLE 1 (CONT.)

Soil Taxonomy					Impact Parameters					Impact Interpretations	Suitability Ratings		
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Tower Foundations	Access Roads	Right of Way
2-38	Dast	Typic Ustorthent	coarse-loamy, mixed, calc., frigid	Custer		20-40	7.6-8.5		n.g.	S	G	F	G
	Scroggim	Ustic Torriorthent	fine-silty, mixed, calcareous, frigid			24-30	8.4-8.9		n.g.				
	Boxwell	Aridic Haploboroll	fine-loamy, mixed				7.0-8.5		cult				
2-39	Scroggim	Ustic Torriorthent	fine-silty, mixed, calcareous, frigid	Prairie & Custer		24-30	8.4-8.9		n.g.	S	G	F	G
	Yawdim	Ustic Torriorthent	clayey, mixed calcareous, shallow			4-20	8.0-8.4		n.g.				
2-40	Lambeth	Ustic Torriorthent	fine-silty, mixed, calc., frigid	Prairie			8.0-8.4		n.g.	S	G	F	G
	Tusler	Ustic Torripsamment	mixed, frigid			20-40	7.8-8.4		n.g.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations			
											Suitability Ratings		
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Tower Foundations	Access Roads	Right of Way
2-26	Lambeth	Ustic Torriorthent	fine-silty, mixed, calc., frigid	Rosebud			8.0-8.4		n.g.	S	G	F	G
	Yamac	Borollic Camborthid	fine-loamy, mixed										
2-41	Yawdim	Ustic Torriorthent	clayey, mixed, calcareous, shallow	Garfield		4-20	8.0-8.4		n.g.	S	G	F	G
2-31	Thebo	Ustertic Torriorthent	fine, mont., calc., mesic	Rosebud		20-40	7.6-8.0		n.g.	S	G	F	G
	Lisam	Ustic Torriorthent	clayey, mont., nonacid, frigid			10-20	7.0-8.4		n.g.				
	Absher	Borollic Natargid	fine, mont.			> 60	6.6-8.5		n.g.				
2-42	Beauvais	Aridic Argiustoll	fine-silty, mixed, mesic	Big Horn			7.0-8.4			S	G	F	G
	Colby	Ustic Torriorthent	fine-silty, mixed, calc., mesic										

TABLE 1

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
2-29	Nelson	Ustic Torriorthent	coarse-loamy, mixed, mesic	Treasure &	<10	20-40	8.2-8.4		Wet.	S	G	F	G
	Alice	Aridic Haplustoll	coarse-loamy, mixed, mesic	Big Horn									
2-43	Cushman	Ustollic Haplargid	fine-loamy, mixed, mesic	Custer		20-40	6.6-8.4	M	n.g.	S	G	F	G
	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow			10-20	7.9-8.4	H	n.g.				
	Shingle	Ustic Torriorthent	loamy, mixed calcareous, mesic, shallow		0-5	10-20	8.0-8.2		R				
2-44	McRae	Ustollic Camborthid	fine-loamy, mixed, mesic	Prairie		48-76	7.9-8.4	L	Cult.	S	G	F	G
2-45	Baineville	Ustic Torriorthent	fine-silty, mixed, mesic, calcareous	Custer & Rosebud		20-40	7.9-9.0	L		S	G	F	G
	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow			10-20	7.9-8.4	H	n.g.				
	Shale Rock Outcrop												
2-30	Vananda	Ustic Torriorthent	fine, mont., calc.,mesic	Treasure		>60	8.0-9.2	H		S	G	F	G
	Lismas	Ustic Torriorthent	clayey, calc., frigid, shallow			10-20	7.4-8.4	H	n.g.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations			
											Suitability Ratings		
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
2-11	Baineville	Ustic Torriorthent	fine-silty, mixed, mesic, calcareous	Yellowstone & Treasure		20-40	7.9-9.0	L		S	G	F	G
2-28	Thedalund	Ustic Torriorthent	fine-loamy, mixed, mesic, calcareous	Rosebud & Big Horn	0-15		8.0-8.4		n.g.	S	G	F	G
	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow			10-20	7.9-8.4	H	n.g.				
Soils of the Plains---#3													
3-3	Shingle	Ustic Torriorthent	loamy, mixed, calcareous, mesic, shallow	Powder River	0-5	10-20	8.0-8.2		R				
	Remmit	Ustollic Camborthid	coarse-loamy, mixed, mesic			>60	7.4-9.0	M	n.g.	S	G	P	F
	Oceanet	Typic Torriorthent	loamy, mixed, calc., mesic, shallow										
3-2	Badlands			Prairie & Custer						S	G	P	F
Soils of the Plains---#5													

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/ Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
5-23	Farland	Typic Argiboroll	fine-silty, mixed	Powder River		>60	6.6-8.4	L	n.g.	S			
	Cabba	Typic Ustorthent	loamy, mixed, calc.,frigid			< 20	7.9-8.4	L	n.g.				
5-21	Ringling	Typic Haploboroll	fragmental, mixed	Big Horn &	30-80	5-20	7.4-8.4	L	n.R.	S			
	Searing	Typic Haploboroll	fine-loamy, mixed	Rosebud		20-40	7.6-8.4		cult.				
5-24	Doney	Typic Ustorthent	fine-loamy, shallow	Big Horn	0-35	20-30	7.9-8.4		n.g.				
	Reeder	Typic Argiboroll	fine-loamy, mixed			30-40	7.6-8.3		Cult.	S			
	Wayden	Typic Ustorthent	clayey, mont., calcareous, frigid, shallow			10-20	7.2-8.2		n.g.				
5-20	Wayden	Typic Ustorthent	clayey, mont., calcareous, frigid, shallow	Big Horn		10-20	7.2-8.2		n.g.	S			
	Regent	Typic Argiboroll	fine, mont.			30-40	7.0-8.2		cult.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters						Impact Interpretations: Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH	Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
5-25	Abac	Typic Ustorthent	loamy, mixed, calc.,shallow	Big Horn	15-35	6-20	7.8-8.5				S			
5-26	Dast	Typic Ustorthent	coarse-loamy calc., frigid	Big Horn		20-40	7.6-8.5			n.g.	S			
	Vebar	Typic Haploboroll	fine, mixed, hyperthermic			20-40				n.g.				
5-27	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow	Big Horn		10-20	7.9-8.4		H	n.g.	S			
	Nunn	Aridic Argiustoll	fine, mont., mesic				7.2-9.2		L	n.g.				
5-22	Wibaux	Ustic Torriorthent	loamy-skeletal mixed, non-acid, mesic	Big Horn & Rosebud			7.6-8.4		L	n.g.	S			
	Thedalund	Ustic Torriorthent	fine-loamy, mixed, mesic, calcareous		0-15		8.0-8.4			n.g.				
	Spearman	Aridic Haplustoll	fine-loamy, fragmental, mixed		0-35	20-40	7.6-8.2			n.g.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations			
											Suitability Ratings		
Series Unit #	Series	Subgroup	Textural Family	County	%Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/ Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
5-18	Wanetta	Ustollic Haplargids	sandy-skeletal, mixed, mesic	Yellowstone	0-30	>60	7.4-8.4	L	n.R.	S			
	Keiser	Ustollic Haplargids	fine-silty, mixed, mesic			>60	6.6-8.5	M	n.g.				
5-16	Pierre	Ustertic Camborthid	very-fine, mont., mesic	Big Horn		20-40	7.9-8.4	H		S			
	Lismas	Ustic Torriorthent	clayey, calc., frigid, shallow			10-20	7.4-8.4	H	n.g.				
	Kyle	Ustertic Camborthid	very-fine, mont., mesic			40-60	7.4-9.0	H	n.g.				
5-28	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow	Powder River		10-20	7.9-8.4	H	n.g.	S			
	Thurlow	Ustollic Haplargids	fine, mont., mesic			>60	6.6-8.4	M	n.g.				
5-29	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow	Rosebud		10-20	7.9-8.4	H	n.g.	S			

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations Suitability Ratings			
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
5-30	Vananda	Ustic Torriorthent	fine, mont., calc., mesic	Big Horn		>60	8.0-8.8		n.g.	S			
	Midway	Ustic Torriorthent	clayey, calc, frigid, shallow			10-20	7.9-8.4	H	n.g.				
	Thedalund	Ustic Torriorthent	fine-loamy, mixed, calc., mesic		0-15		8.0-8.4		g				
5-7	Thedalund	Ustic Torriorthent	fine-loamy, mixed, calc., mesic	Yellowstone & Musselshell	0-15		8.0-8.4		g	S			
	Travesilla	Lithic Ustic Torriorthent	loamy-mixed, calc., mesic		0-35	10-20	6.6-7.3	L	R				
5-31	Wanetta	Ustollic Haplargids	sandy-skeletal, mixed, mesic	Rosebud & Treasure	0-30	>60	7.4-8.4	M	R	S			
	Hesper	Ustollic Haplargid	fine, mont., mesic			>60	6.6-9.0	M-L	n.g.				
5-8	Worland	Typic Torriorthent	coarse-loamy, mixed, mesic, calcareous	Yellowstone	0-15	20-40	7.9-8.4	L	R	S			
	Baineville	Ustic Torriorthent	fine-silty, mixed, mesic, calcareous			20-40	7.9-9.0	L					

TABLE 1 (Cont.)

Series Unit #	Soil Taxonomy: Series	Subgroup	Textural Family	County	Impact Parameters: % Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Impact Interpretations: Erosion Hazard	Suitability Ratings: Foundations	Access Roads	Right of Way
5-14	Midway	Ustic Torriorthent	clayey, calc., frigid, shallow	Musselshell		10-20	7.9-8.4	H	n.g.	S			
	Baineville	Ustic Torriorthent	fine-silty, mixed, mesic			20-40	7.9-9.0	L					
Soils of the Plains---#6													
6-1	Thebo	Ustertic Torriorthent	fine, mont., calc., mesic	Rosebud & Garfield		20-40	7.6-8.0		n.g.	S			
	Lisam	Ustic Torriorthent	clayey, mont., nonacid, frigid			10-20	7.0-8.4		n.g.				
	Absher	Borollic Natargid	fine, mont.			>60	6.6-8.5		n.g.				
6-2	Hogbacks			Rosebud & Garfield						S			
Soils of the Alluvial Lands (floodplains) #1-2													
1-17	Trembles	Typic Ustifluvent	coarse-loamy, mixed, calc., frigid	Prairie			7.8-8.4		cult.	SL	F-G	F-G	F-G
	Havrelon	Typic Ustifluvent	fine-loamy, mixed, calc., frigid			>60	7.4-8.4	L	cult.				
	Lohler	Typic Ustifluvent	fine, mont., calc., frigid				7.8-8.2		cult.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations			
											Suitability Ratings		
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/ Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
1-4	Haverson	Ustic Torrifluvent	fine-loamy, mixed, calc., frigid	Yellowstone Treasure,	<5	>60	7.9-8.4	M-H		SL	F-G	F-G	F-G
	Lohmiller	Ustic Torrifluvent	fine, mont. mesic	Rosebud, & Custer		>60	7.9-9.0	H	cult.				
1-18	Harlem	Ustic Torrifluvent	fine, mont., calc.	Garfield & Rosebud			7.9-8.7		cult.	SL	F-G	F-G	F-G
1-15	Havre	Ustic Torrifluvent	fine-loamy, mixed, calc., frigid	Rosebud			8.2-8.6	M-L	cult.	SL	F-G	F-G	F-G
	Harlem	Ustic Torrifluvent	fine, mont., calc.				7.9-8.7		cult.				
1-19	Havre	Ustic Torrifluvent	fine-loamy, mixed, calc., frigid	Garfield			8.2-8.6	M-L	cult.	SL	F-G	F-G	F-G
	Glendive	Ustic Torrifluvent	coarse-loamy, mixed, calc., frigid				8.2-8.8	L	cult.				

TABLE 1 (Cont.)

Soil Taxonomy					Impact Parameters					Impact Interpretations			
											Suitability Ratings		
Series Unit #	Series	Subgroup	Textural Family	County	% Coarse Fragment	Depth to Bedrock	pH Fertility	Shrink/Swell	Tilth	Erosion Hazard	Foundations	Access Roads	Right of Way
1-16	Lohmiller	Ustic Torrifluvent	fine, mont., mesic	Big Horn		>60	7.9-9.0	H	cult.	SL	F-G	F-G	F-G
	Kyle	Usteric Camborthid	very-fine, mont., mesic			40-60	7.4-9.0	H	n.g.				
	Haverson	Ustic Torrifluvent	fine-loamy, mixed, calc., frigid		<5	>60	7.9-8.4	M-H					
1-20	Korchea	Typic Ustifluvent	fine-loamy, mixed, calc.	Big Horn			8.0-8.2		cult.	SL	F-G	F-G	F-G
	Farnuf	Typic Argiboroll	fine-loamy, mixed				7.4-8.5		n.g.				
	Savage	Typic Argiboroll	fine, mont.		0-15		7.4-9.0	M-H	n.g.				
1-21	Cherry	Typic Ustochrept	fine-silty, mixed, frigid	Prairie		>60	8.0-8.6	M	n.g.	SL	F-G	F-G	F-G

C2 Chemical Analysis of Study Area Soil

Sample Collection

The soil samples were collected in May (1974), by the Air Quality Bureau. A soil sampling corer from Elano Corporation of Xenia, Ohio, was used to extract the soil cores. At each site eight cores were extracted at random within a 2x6 meter plot. Each core was separated into an A_1 and B_2 horizon. Corresponding horizons from these eight cores were mixed and a sampling analysis was taken. Thus a compound A_1 horizon and a B_2 horizon sample was extracted from each sampling plot. The size of the eight constituent cores forming the final sample varied somewhat within each sampling plot due to slight differences in horizon thicknesses. The intraplot variation between horizons was somewhat less than in interplot variations. The A_1 and B_2 horizon samples were placed in plastic sample bags and labelled.

Laboratory Analysis

The pH of the soil samples was determined using an electrode pH meter. Twenty ml of deionized water was added to each 10g field sample. The pH was determined by lowering the electrode into a beaker containing the soil-water mixture. This standard method is sensitive within a range of 0.1 pH.

The following elements were analyzed using Flame Atomic Absorbtion: Na, K, Ca, Mg, Li, Sr, Cu, Zn, Fe, Cr and Mn. Following preliminary hydrolysis, ashing, and dissolving, the following elements are analyzed using a carbon rod atomizer: Sn, Sb, V, Ag, Be, Pb, Cd, and Hg. This technique ensures increased efficiency and sensitivity in determining trace element amounts. The atomic absorbtion spectrophotometer used in these analyses was a Varian Techtron Model 1200 for flame atomic absorption. The Varian Techtron Model 63 carbon rod atomizer was used for flameless atomic absorbtion.

Sample Analysis

Results of the soil analysis are included in Tables 1, 2, 3 and 4. Included are data on twenty-two elements plus pH determinations. The pH data (Table 4) indicates a typical alkaline pH expected in arid soils (Lyon et al. 1952). Note that the pH of the A_1 horizon was less alkaline than the pH of the B_2 horizon.

The concentration of elements analyzed in the soil samples are presented in Tables 1, 2 and 3. Note that the concentrations are in ppm except where an asterisk indicates the concentrations of the elements in 10^{-3} ppm. The elements found in highest concentration in the soil include Fe, Ca, K, Mg, Na, F, and Mn, in that order. Arithmetic means and standard deviation are indicated at the end of the tables for each element. Tremendous variation is found among some of these elements, but this is in agreement with expectations for soil samples taken in areas of different aspects and vegetation cover. Trace elements such as Se, Sb, Be, Ag, and Cd show much less variation from site to site. The concentrations of trace elements Sb, Sn, and Pb were below the detectability limits of the method. There were no consistent trends between the concentration of elements found in the upper and lower soil horizons. This was true despite the findings with the soil pH.

The high concentrations of Na, K, Ca, Mg, and Fe found in the samples is consistent with the importance of these elements in soil minerals (Lyon et al. 1952). Both Mg and Ca are found in typically high concentration in arid soils. The order of concentration of K, Ca, and Mg in arid soils was expected to be K> Ca> Mg. With these samples this held true for Ca and Mg but not for K.

TABLE 1

COLSTRIP SOIL SAMPLE ANALYSES DATA
COLLECTED BY AIR QUALITY BUREAU

Site**		Na*	K*	Ca*	Mg*	Sr ppm	Li ppm	Se ppm	Zn ppm	Fe*	Cr ppm	Mn ppm	Cu ppm
N1	T	7.7	17	36	6	32	<.25		63	21	26	270	<25
	B	7.8	22	26	10	50	22	<.6		22	43	160	13
N2	T	11	16	32	11	56	<.25		57	19	25	400	<25
	B	9	17	60	15	120	<50	<0.5	60	20		410	<25
N3	T	9	17	9.5	6	155	<50	<0.5	58	21	49	590	<25
	B												
N4	T	22	20	16	7.3	280	19	<0.6		31	56	300	20
	B	13	16	12.5	5.5	225	<50	<0.5	51		48	390	<25
NE1	T	7.8	21	30	9.7	70	17	<0.6		24	46	310	15
	B	7.5	18	60	12	130	<50	<0.5	56	13		390	<25
NE2	T	12.6	15	47	15	110	<.25		56	21	36	1000	<25
	B	13	19				19	<0.6		26	42	370	14
NE3	T	11	19	14	9.2	100	17	<0.6		29	44	350	19
	B	14	21	56	14	140	22	<0.6		28	44	450	22
NE4	T	6.4	16	3.9	4.3	95	<50	<0.5	48	16	28	340	<25
	B	16	21	7.3	7.1	140	17	<0.6		23	14	240	24
E 1	T												
	B	7.2	20	21	13.5	120	<50	<0.5	45	22	39	600	<25
E 2	T	11	20	42	12	70	19	<0.6		24	33	1.80	13
	B	9.5	20	44.5	13	35	<50	<0.5	46	19	26	260	<25

* = ppm x $\frac{1}{1000}$

**T = A_1 Horizon
B = B_2 Horizon

TABLE 1 (Cont.)

Site**	NA*	K*	Ca*	Mg*	Sr ppm	Li ppm	Se ppm	Zn ppm	Fe*	Cr ppm	Mn ppm	Cu ppm
E 3 T	8.9	9.2	15.5	11.5	120	<50	<0.5	49	16		340	<25
B	12	20	38	17	80	22	<0.6		23	36	210	16
E 4 T	8.2	20	31	14	71	<.25		72	26	47	530	<25
B	7.1	21	46.5	1.5	90	<50	<0.5	82	28		470	<25
SE 1 T												
B	9.4	17	58	19	63	<0.25	-	48	22	37	340	<25
SE 2 T	7.8	18	43	19	60	<0.25	-	71	22	38	390	<25
B	8.1	18	49	21	60	<0.25	-	72	22	37	410	<25
SE 3 T	9.3	20	89	10	120	<0.25	-	131	34	62	770	<25
B	11	25	22	19	160	30	<0.6	-	38	73	410	50
SE 4 T	6.4	23	42	17	120	27	<0.6	-	35	57	290	40
B	6.4	23	42	26	120	30	<0.6	-	34	65	530	48
S 1 T	6.7	19	23	10	32	<.25	-	65	25	41	1000	<25
B	3.6	16	100	17.5	135	<50	<0.5	64	20	-	330	<25
S 2 T	6	18	47.5	17	100	<50	<0.5	57	13	-	300	<25
B	8.5	17	60	21	105	<50	<0.5	61	20	-	360	<25
S 3 T	8.5	18	66	8	48	<.25	-	45	20	33	370	<25
B	10	20	12	11	55	22	<0.6	-	23	40	180	16

* = ppm x $\frac{1}{1000}$

** T = A_1 Horizon
B = B_2 Horizon

TABLE 1 (Cont.)

Site **	Na*	K*	Ca*	Mg*	Sr ppm	Li ppm	Se ppm	Zn ppm	Fe*	Cr ppm	Mn ppm	Cu ppm
S 4 T	7.6	20	48	20.5	120	<50	<0.5	61	20	-	340	<25
B	8.8	18	46	16	52	<.25	-	56	20	38	360	<25
SW 1 T	7.1	18	41.5	20	105	<50	<0.5	62	23	-	360	<25
B	8.4	19	17	10	75	<.25	-	76	26	41	620	<25
SW 2 T												
B												
SW 3 T	9.8	17	22	12	20	<0.25	-	-	20	35	380	<25
B	8.2	16	37	10	40	<0.25	-	56	21	32	550	<25
SW 4 T												
B												
W 1 T												
B	7.8	23.0	4.8	7.0	40	<50	<0.5	71	25	-	580	<25
W 2 T												
B	5.6	-	32	18	70	<50	<0.5	50	20	46	350	<25
W 3 T	6.9	19.0	20.5	13	110	<50	<0.5	45	20	37	360	<25
B	8.1	19.0	45	12	125	<50	<0.5	71	25	-	330	<25
W 4 T	5.9	15.0	40	13.5	175	<50	<0.5	62	25	52	350	<25
B	7.7	18	85	20	240	25	<.6	-	31	60	240	26

$* = \text{ppm} \times \frac{1}{1000}$

** T = A_1 Horizon
B = B_2 Horizon

TABLE 1 (Cont.)

Site **	Na*	K*	Ca*	Mg*	Sr ppm	Li ppm	Se ppm	Zn ppm	Fe*	Cr ppm	Mn ppm	Cu ppm
NW 1 T	12	18.0	47	14	71	<.25	<1	50	20	29	320	<25
B	8.8	18.0	55	16	100	<50	<0.5	49	18	31	290	<25
NW 2 T	6.5	18.0	16	10	135	<50	<0.5	57	19	39	600	<25
B	7.2	17.0	26	11.5	175	<50	<0.5	78	36	-	580	<25
NW 3 T												
B	10.0	17.0	80.0	13.5	130	<50	<0.5	56	18	-	650	<25
NW 4 T	10	16	9.5	6	105	<50	<0.5	49	18	28	350	<25
B	14	23	20	11	150	25	<0.6	-	31	47	300	21
NW 5 T	-	-	14.5	6	300	<50	<0.5	52	21	44	420	<25
B	14.0	16.0	12.5	5.5	165	<50	<0.5	73	26	-	450	<25
$\bar{X}$	9.23	18.5	22.1	12.7	109.5	17.6	0.3	60.7	23.3	41.8	411	15.6
SD	3.04	2.6	36.8	5.13	58.2	10.94	0.04	15.1	5.5	10.9	170	8.1

$* = \text{ppm} \times \frac{1}{1000}$

** T = A_1 Horizon
B = B_2 Horison

SD = Standard Deviation
$\bar{X}$ = Arithmetic Means

TABLE 1 (Cont.)

Site**		As ppm	Hg ppm	Su ppm	Sb ppm	V ppm	Ag ppm	Be ppm	Pb ppm	Cd ppm	F ppm
N1	T	2.8	.09	<10	<3	20	<0.5	<0.2	<0.5	<0.05	334
	B	1.8	.09	<10	<3	23	<0.3	<0.2	<0.5	<0.05	364
N2	T	3.8	.26	<10	<3	10	<0.5	<0.2	<0.5	<0.05	353
	B	2.4	.06	<10	<5	9	<0.2	<0.1	<0.5	<0.1	364
N3	T	1.6	.13	<10	<5	22	<0.2	<0.1	<0.5	<0.1	257
	B										
N4	T	2.5	<.09	<10	<3	93	<.03	<0.2	<0.5	<0.05	364
	B	0.8	.52	<10	<5	25	<0.2	<0.1	<0.5	<0.1	250
NE1	T	4.8	<.09	<10	<3	43	<0.3	<0.2	<0.5	<.05	671
	B	0.5	0.6	<10	<5	3	<0.2	<0.1	<0.5	<0.1	834
NE2	T	33.2	.09	<10	<3	5	<0.5	<0.2	<0.5	<0.05	228
	B	2.5		<10	<3	60	<0.3	<0.2	<0.5	<0.05	326
NE3	T	2.4		<10	<3	63	<0.3	<0.2	<0.5	<0.05	649
	B	2.6	<.09	<10	<3	15	<0.3	<0.2	<0.5	<0.05	363
NE4	T	2.2	<.06	<10	<5	12	<0.2	<0.1	<0.5	<0.1	646
	B	4.8	<.09	<10	<3	43	<0.3	<0.2	<0.5	<0.05	271
E 1	T										
	B	4.2	<.06	<10	<5	12	<0.2	<0.1	<0.5	<0.1	383
E 2	T	2.8	<.09	<10	<3	23	<0.3	<0.2	<0.5	<.05	353
	B	2.4	.06	<10	<5	3	<0.2	<0.1	<0.5	<0.1	397

* - ppm x $\frac{1}{1000}$

** T = A_1 Horizon
B = B_2 Horizon

TABLE 1 (Cont.)

Site**		As ppm	Hg ppm	Su ppm	Sb ppm	V ppm	Ag ppm	Be ppm	Pb ppm	Cd ppm	F ppm
E 3	T	2.1	.06	<10	<5	9	<0.2	<0.1	<0.5	<0.1	603
	B	4.7	.18	<10	<3	8	<0.3	<0.2	<0.5	<0.05	320
E 4	T	0.6	<.09	<10	<3	35	<0.5	<0.2	<0.5	<0.05	606
	B	1.4	20	<10	<5	25	<0.2	<0.1	<0.5	<0.1	565
SE1	T										
	B	3.5	.09	<10	-	5	-	<0.2	<.05	<0.05	404
SE2	T	4.2	<.09	<10	<3	45	<0.5	<0.2	<0.5	<0.05	540
	B	6.7	.26	<10	<3	5	<0.5	<0.2	<0.5	<0.05	459
SE3	T	8.3	.18	<10	<3	100	<0.5	<0.2	<0.5	<0.05	507
	B	8.2	<.09	<10	<3	48	<0.3	<0.2	<0.5	<0.05	506
SE4	T	3.3	.26	<10	<3	78	<0.3	<0.2	<0.5	<0.05	539
	B	3.3	<.09	<10	<3	78	<0.3	<0.2	<0.5	<0.05	623
S 1	T	4.6	<.09	<10	<3	45	<0.5		<0.5	<0.05	547
	B	1.3	.46	<10	<5	9	<0.2	<0.1	<0.5	<0.1	515
S 2	T	2.7	.13	<10	<5	< 3	<0.2	<0.1	<0.5	<0.1	334
	B	1.3	.20	<10	<5	3	<0.2	<0.1	<0.5	<0.1	372
S 3	T	2.2	.35	<10	<3	25	<0.5	<0.2	<0.5	<0.05	327
	B	1.7	.09	<10	<3	33	<0.3	<0.2	<0.5	<0.05	342

** T = A_1 Horizon
B = B_2 Horizon

TABLE 1 (Cont.)

Site **	As ppm	Hg ppm	Sn ppm	Sb ppm	V ppm	Ag ppm	Be ppm	Pb ppm	Cd ppm	F ppm
S 4 T	3.1	.06	<10	<5	22	<0.2	<0.1	<0.5	<0.1	339
B	1.6	<.09	<10	<3	10	<0.5	<0.2	<0.5	<0.05	771
SW1 T	3.8	.06	<10	<5	16	<0.2	<0.1	<0.5	<0.1	426
B	5.0	.18	<10	<3	30	<0.5	<0.2	<0.5	<0.05	342
SW2 T										
B										
SW3 T	4.0	.20	<10	<3	30	<0.5	-	<0.5	<0.05	507
B	5.2	-	40	<3	25	<0.5	-	<0.5	<0.05	360
SW4 T										
B										
W 1 T										
B	4.4	.52	<10	<5	6	<0.2	<0.1	<0.5	<0.1	394
W 2 T										
B	1.5	.06	<10	<5	6	<0.2	<0.1	<0.5	<0.1	488
W 3 T	1.3	<.06	<10	<5	6	<0.2	<0.1	<0.5	<0.1	367
B	1.8	.06	<10	<5	6	<0.2	<0.1	<0.5	<0.1	394
W 4 T	3.4	.06	<10	<5	22	<0.2	<0.1	<0.5	<0.1	378
B	5.1	-	<10	<3	8	< .3	< .2	<0.5	<0.05	507

** T = A_1 Horizon
B = B_2 Horizon

TABLE 1 (Cont.)

Site**	As ppm	Hg ppm	Sn ppm	Sb ppm	V ppm	Ag ppm	Be ppm	Pb ppm	Cd ppm	F ppm
NW1 T	5.6	.35	<10	<3	10	<0.5	<0.2	<0.5	<0.05	320
B	0.5	.13	<10	<5	3	<0.2	<0.1	<0.5	<0.1	323
NW2 T	4.4	<.06	<10	<5	22	<0.2	<0.1	<0.5	<0.1	393
B	2.4	.06	<10	<5	25	<0.2	<0.1	<0.5	<0.1	353
NW3 T										
B	0.7	.06	<10	<5	3	<0.2	<0.1	<0.5	<0.1	394
NW4 T	1.0	.13	<10	<5	16	<0.2	<0.1	<0.5	<0.1	345
B	3.9	.09	<10	<3	80	< .3	< .2	< .5	< .05	485
NW5 T	0.6	.13	<10	<5	20	<0.2	<0.1	<0.5	<0.1	217
B	4.2	.33	<10	<5	25	<0.2	<0.1	<0.5	<0.1	284
$\bar{X}$	31.	.13	5.0	2.0	25.5	.15	.07	0.25	0.03	484.43
SD	1.8	.12	0	0.5	24.1	.06	.02	0	0.01	274.99

** T = A_1 Horizon
B = B_2 Horizon

SD = Standard Deviation
$\bar{X}$ = Arithmetic Means

TABLE 2

pH OF SOIL SAMPLES FROM COLSTRIP

	Horizon A_1			Horizon B_2	
Site	pH	Mean Depth (in.)	Site	pH	Mean Depth (in.)
N1	8.3	1.5	N1	8.9	4.5
N2	8.5	1.5	N2	8.8	4.5
N3	6.8	1.5	N3	8.1	4.5
NE1	8.4	1.5	NE1	8.7	4.5
NE2	8.5	1.5	NE2	8.8	4.5
NE3	8.4	1.5	NE3	8.8	4.5
NE4	--		NE4	7.4	4.5
E1	--		E1	8.6	4.5
E2	8.4	1.5	E2	8.9	4.5
E3	8.4	1.5	E3	8.9	4.5
E4	8.4	1.5	E4	8.6	4.5
SE2	--		SE2	8.6	4.5
SE3	--		SE3	8.0	4.5
S1	8.6	1.5	S1	8.6	4.5
S4	8.5	1.5	S4	8.9	4.5

TABLE 2 (Cont.)

Site	pH	Horizon A_1 Mean Depth (in.)	Site	pH	Horizon B_2 Mean Depth (in.)
SW1	8.4	1.5	SW1	8.6	4.5
SW3	8.7	1.5	SW3	--	
W1	8.7	1.5	W1	7.9	4.5
W2	8.4	1.5	W2	8.6	4.5
W3	8.7	1.5	W3	8.7	4.5
W4	8.5	1.5	W4	8.8	4.5
NW1	7.9	1.5	NW1	8.9	4.5
NW2	8.5	1.5	NW2	8.6	4.5
NW3	8.4	1.5	NW3	8.9	4.5
NW4	8.0	1.5	NW4	8.7	4.5

$\bar{x} = 8.4$* $\bar{x} = 8.6$*

*significant at 0.025

APPENDIX D: Vegetation

Appendix D 1
VEGETATION COLLECTED

FORBS

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Yarrow	X	X			X			X	X	X			X	
Wild onion					X				X			X		
Textile onion											X			
<u>Alyssum desertorum</u>		X												X
Perennial ragweed	X	X	X				X	X	X	X	X			
Small-leaf pussytoes	X									X		X	X	X
Rock cress				X										
Prickly poppy											X			
Tarragon sagewort		X	X	X		X		X	X	X		X	X	X
Fringed sage	X	X	X		X	X	X	X	X	X	X	X	X	X
Cudweed sagewort	X	X	X	X			X	X		X	X	X	X	
Showy milkweed		X							X		X			
Green milkweed		X	X	X					X		X			
Creeping white prairie aster								X						

FORBS (Continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Fuzzytongue penstemon							X		X					
Waxleaf penstemon		X	X	X	X	X				X				
Purple prairie clover	X		X	X	X	X	X	X	X	X	X	X	X	
Silverleaf phacelia				X	X									
Phlox alsyssifolia			X		X									
Hoods phlox	X	X	X	X	X	X	X	X	X	X		X	X	X
Patogonia indianwheat		X		X	X		X	X	X	X		X	X	X
White milkwort						X								
Silverleaf scurfpea	X	X		X	X			X	X				X	
Breadroot scurfpea	X	X		X	X	X	X		X	X	X	X		
Slimflower scurfpea			X			X	X			X	X	X		X
Woolly groundsel			X		X		X				X			
Prairie groundsel			X						X		X	X		
Starry false Solomon's seal		X												
Missouri goldenrod		X					X	X	X	X	X	X		

FORBS (Continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW1	EPA SITE	EPA-KLUVER
Lupine												X		
Rush skeletonweed	X	X		X							X			
Machaeranthera grindelioides			X		X		X							
White sweetclover						X					X			
Yellow sweetclover						X					X			
Ten petal blazing star			X		X									
Horse mint												X		
Wild parsley		X												
Shrubby evening primrose				X	X		X		X		X			
Brittle pricklypear											X			
Plains pricklypear	X					X	X		X	X		X		X
Tuffed broomrape												X		
Yellow owlclover	X	X						X				X	X	
Locoweed		X	X			X	X	X	X			X		
Nailwort					X									

FORBS (Continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Curlycup gumweed	X					X	X	X	X			X		X
Stemless goldenweed			X		X	X								
Spiny goldenweed									X					
Drummond false pennyroyal			X		X									
Common sunflower											X			
Stiff sunflower		X												
Prairie sunflower						X								
Rag sumpweed		X	X	X	X	X	X		X					
Lettuce		X				X				X	X		X	X
Pepperweed		X							X	X				
Alkaline bladderpod			X	X	X			X						
Dotted blazingstar		X	X	X	X	X	X	X	X		X	X		
Perennial flax	X				X		X	X	X	X	X			
Stemless flax					X	X	X	X	X	X	X	X	X	
Narrowleaf gromwell				X		X				X	X	X		

FORBS (Continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Aster								X			X	X	X	
Threeleaved milkvetch							X	X				X	X	
Tufted milkvetch				X		X								
Milkvetch	X	X		X		X	X		XX		XX	XX	XX	X
Arrowleaf balsamroot		X												
Red kitten-tail		X												
Brickellia oblongifolia	X	X			X		X	X	X			X		
Sego lily		X		X				X	X	X		X		
Field chickweed	X	X			X			X			X	X	X	
Hairy goldenaster	X	X		X		X	X		X		X	X		
Canada thistle				X										
Cirsium flodmanii											X	X		
Wavyleaf thistle	X	X	X	X	X	X	X	X	X	X		X	X	X
Horseweed											X		X	
Miners candle			X		X	X		X						

FORBS (Continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Hawk's-beard		X												
Purple coneflower	X	X		X	X		X	X	X			X	X	
Fernleaf fleabane		X			X									
Spreading fleabane						X								
Erigeron ochroleucus				X				X				X		
Erigeron strigosus	X			X			X						X	
Wild buckwheat				X		X	X			X	X			
Yellow buckwheat				X										
Eriogonum pauciflorum		X	X		X		X		X					
Sun spurge			X	X										
Evolvolus Nuttalliianus								X	X		X			X
Gaillardia	X								X					
Scarlet gaura		X		X	X		X		X	X	X	X	X	
Prairiesmoke		X								X				
Bullhead gilia			X	X	X									
Wild licorice												X		

FORBS (continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Stiff goldenrod	X													
Scarlet globemallow						X				X	X	X	X	X
Greenthread											X			
Townsendia					X									
Common salsify	X	X	X	X		X	X	X	X	X	X	X	X	X
Death camas	X				X		X	X		X	X	X	X	

GRASSES & SEDGES

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Blue grama	X	X		X	X	X	X	X		X	X	X	X	X
Japanese bromegrass	X	X		X		X	X	X	X		X	X	X	X
Cheatgrass brome	X	X	X	X	X	X	X	X	X		X	X	X	X
Plains reedgrass							X						X	
Prairie sandreed	X	X	X	X			X			X	X	X		
Needleleaf sedge		X												
Threadleaf sedge	X	X		X	X	X	X	X	X	X	X	X		X
Sedge	X		X								X	X		
Idaho fescue		X											X	
Six-week fescue				X		X		X			X	X	X	
Foxtail barley											X			
Prairie junegrass	X	X	X	X		X	X	X	X	X	X		X	X
Indian ricegrass					X		X	X	X	X	X			
Canada bluegrass		X						X	X	X		X		
Kentucky bluegrass												X		
Crested wheatgrass		X												
Western wheatgrass	X	X				X		X		X	X	X	X	X
Bluebunch wheatgrass	X	X	X	X	X	X	X	X	X	X	X	X	X	

GRASSES & SEDGES (continued)

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Big bluestem				X						X	X			
Little bluestem	X	X	X	X	X	X	X	X	X	X	X			
Red three-awn	X	X		X		X		X	X	X	X	X	X	X
Side-oats grama	X	X		X	X		X	X	X	X	X			
Native bluegrass	X	X	X	X			X	X	X		X		X	X
Needle-and-Thread	X	X		X		X	X	X	X	X	X	X	X	X
Green needlegrass		X						X	X	X	X			

SHRUBS, SEMI-SHRUBS, AND BUSHES

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Silver sagebrush	X	X	X		X	X	X	X	X	X	X	X	X	
Big sagebrush	X		X		X	X	X		X			X		
Nuttal saltbush	X						X							
Rubber rabbitbrush									X					
Green rabbitbrush	X	X	X	X	X	X	X	X	X		X	X	X	
Winterfat					X									
Horizontal juniper					X						X	X		
Chokecherry										X		X		
Skunkbush sumac	X	X	X	X	X		X	X	X	X	X	X	X	
Poison ivy		X	X											
Golden currant										X	X			
Wax currant			X											
Prairie rose					X							X		
Woods rose		X						X	X			X		
Western snowberry	X	X								X		X		
Soapweed	X	X	X	X	X	X	X	X	X	X	X	X		

TREES

SPECIES	S4	SE4	SE5	E5	E4	NE4	NE3	W1	N1	SE1	W2	NW3	EPA SITE	EPA-KLUVER
Rocky Mountain juniper	X	X	X	X			X	X	X	X	X	X		
Ponderosa pine	X	X	X	X	X		X	X	X	X	X	X		
Plains cottonwood						X								

APPENDIX D2

Vegetation Species List
* Noxious
** Poisonous

TREES

Black cottonwood	*Populus trichocarpa*
Boxelder	*Acer negundo*
Douglas fir	*Pseudotsuga menziesii*
Eastern white pine	*Pinus strobus*
Green ash	*Fraxinus pennsylvanica*
Horizontal juniper	*Juniperus horizontalis*
Limber pine	*Pinus flexilis*
Lodgepole pine	*Pinus contorta*
Plains cottonwood	*Populus deltoides*
Ponderosa pine	*Pinus ponderosa*
Quaking aspen	*Populus tremuloides*
Rocky Mountain juniper	*Juniperus scopulorum*
Scotch pine	*Pinus sylvestris*
Virginia pine	*Pinus virginiana*
Willow	*Salix* spp.

SHRUBS

Big sagebrush	Artemisia tridentata
Big whortleberry	Vaccinium membranaceum
*Broom snakeweed	Gutierrezia sarothrae
Buffaloberry	Shepherdia canadensis
Chokecherry	Prunus virginiana
Dogwood	Cornus stolonifera
Dwarf huckleberry	Vaccinium caespitosum
Fleshy hawthorn	Crataegus succulenta
Four wing saltbush	Atriplex canescens
Fringed sage	Artemisia frigida
Gooseberry currant	Ribes spp.
Golden currant	Ribes aureum
**Greasewood	Sarcobatus vermiculatus
Green rabbitbrush	Chrysothamnus viscidiflorus
Hawthorn	Crataegus douglasii
**Horsebrush	Tetradymia canescens
Longleaf sagebrush	Artemisia longifolia
Nuttal saltbush	Atriplex nuttallii
Oregon grape	Mahonia repens

SHRUBS (continued)

Plains pricklypear	Opunita polyacantha
Poison ivy	Rhus radicans
Prairie rose	Rosa arkansana
*Pricklypear	Opuntia spp.
Rose	Rosa spp.
Rubber rabbitbrush	Chrysothamnus nauseosus
Saltbush	Atriplex spp.
Serviceberry	Amelanchier alnifolia
Shadscale saltbush	Atriplex confertifolia
Shrubby cinquefoil	Potentilla fruticosa
Silver sagebrush	Artemisia cana
Skunkbush sumac	Rhus trilobata
Snowberry	Symphoricarpos albus
Soapweed	Yucca glauca
Thorny buffaloberry	Shepherdia argentea
Wax currant	Ribes cereum
Western snowberry	Symphoricarpos occidentalis
Winterfat	Eurotia lanata
Woods rose	Rosa woodsii

GRASSES & GRASSLIKE

Alkali bluegrass	*Poa juncifolia*
Alkali sacaton	*Sporobolus airoides*
**Arrowgrass	*Triglochin maritima*
Basin wildrye	*Elymus cinereus*
Big bluestem	*Andropogon gerardii*
Bluebunch wheatgrass	*Agropyron spicatum*
Blue grama	*Bouteloua gracilis*
Bluegrass	*Poa* spp.
Buffalograss	*Bocheloe dactyloides*
Canada bluegrass	*Poa compressa*
*Cheatgrass brome	*Bromus tectorum*
Crested wheatgrass	*Agropyron cristatum*
Elk sedge	*Carex geyeri*
Foxtail barley	*Hordeum jubatum*
Green needlegrass	*Stipa viridula*
Idaho fescue	*Festuca idahoensis*
Indian ricegrass	*Oryzopsis hymenoides*
Japanese bromegrass	*Bromus japonicus*
Kentucky bluegrass	*Poa pratensis*

GRASSES & GRASSLIKE (continued)

Lincoln bromegrass	*Bromus inermis*
Little bluestem	*Andropogon scoparius*
Native bluegrass	*Poa secunda*
Needle-and-thread	*Stipa comata*
Needleleaf sedge	*Carex stenophylla*
Nuttall alkaligrass	*Puccinellia airoides*
Orchardgrass	*Dactylis glomerata*
Parry oatgrass	*Danthonia parryi*
Pine reedgrass	*Calamagrostis rubescens*
Plains muhly	*Muhlenbergia cuspidata*
Plains reedgrass	*Calamagrostis montanensis*
Prairie junegrass	*Koeleria cristata*
Prairie sandreed	*Calamouilfa longifolia*
Red three-awn	*Aristida longiseta*
Reed canary grass	*Phalaris arundinacea*
Richardson's needlegrass	*Stipa richardsonii*
Rough fescue	*Festuca scabrella*
Saltgrass	*Distichlis stricta*
Sedge	*Carex* spp.

GRASSES & GRASSLIKE (continued)

Side-oats grama	*Bouteloua curtipendula*
Six-week fescue	*Festuca octoflora*
Slender wheatgrass	*Agropyron trachy caulum*
Soft chess	*Bromus mollis*
Squirreltail	*Sitanion hysterix*
Tall wheatgrass	*Agropyron elongatum*
Thickspike wheatgrass	*Agropyron dasystachyum*
Threadleaf sedge	*Carex filifolia*
Timber oatgrass	*Danthonia intermedia*
*Tumblegrass	*Schedonnardus paniculatus*
Western wheatgrass	*Agropyron smithii*
Wire rush	*Juncus balticus*

FORBS

Alfalfa	*Medicago sativa*
Alkaline bladderpod	*Lesquerella alpina*
American vetch	*Vicia americana*
Aromatic aster	*Aster oblongifolius*
Arrowleaf balsamroot	*Balsamorhiza sagittata*
Aster	*Aster* spp.

FORBS (continued)

Ballhead gilia	*Gilia congesta*
Blazing star	*Mentzelia* spp.
Bluebell	*Mertensia* spp.
Breadroot scurfpea	*Psoralea esculenta*
Brittle pricklypear	*Opuntia fragilis*
*Burdock	*Artium lappa*
*Canada thistle	*Cirsium arvense*
Cicer milkvetch	*Astragalus cicer*
*Clubmoss	*Selanginella* spp.
**Cocklebur	*Xanthium strumarium*
Common salsify	*Tragopogon dubius*
Common sunflower	*Helianthus annuus*
Creeping white prairie aster	*Aster falcatus*
Cudweed sagewort	*Artemisia ludoviciana*
Curlycup gumweed	*Grindelia squarrosa*
*Dalmatian toadflax	*Linaria dalmatica*
Dandelion	*Taraxacum officinale*
**Death camas	*Zigadenus venenosus*
Dotted blazingstar	*Liatris punctata*

FORBS (continued)

Drummond false pennyroyal	_Hedeoma drummondii_
False Solomon's seal	_Smilacina racemosa_
Fernleaf fleabane	_Erigeron compositus_
*Field bindweed	_Convolvulus arvensis_
Field chickweed	_Cerastium arvense_
Field mint	_Mentha arvensis_
Fuzzytongue penstemon	_Penstemon eriantherus_
Gaillardia	_Gaillardia aristata_
Golden current	_Ribes_ spp.
Green milkweed	_Asclepias verticillata_
Greenthread	_Thelasperma_ spp.
Hairy goldenaster	_Chrysopsis villosa_
Heartleaf arnica	_Arnica cordifolia_
Hawk's-beard	_Crepis_ spp.
Hoods phlox	_Phlox hoodii_
Horse mint	_Monarda fistulosa_
Horseweed	_Conyza canadensis_
*Lambsquarter goosefoot	_Chenopodium album_
**Leafy spurge	_Euphorbia esola_

FORBS (continued)

Lettuce	*Lactuca* spp.
**Locoweed	*Oxytropis* spp.
**Low larkspur	*Delphinium bicolor*
**Lupine	*Lupinus* spp.
Milkvetch	*Astragalus* spp.
Milkweed	*Asclepius viridiflora*
Miners candle	*Crysptantha celosioides*
Missouri goldenrod	*Solidago missouriensis*
Nailwort	*Paronychia sessiliflora*
Narrow leaved Collomia	*Collomia linearis*
Narrowleaf gromwell	*Lithospermum incisum*
Nuttall goldenweed	*Haplopappus nuttallii*
Nuttal monolepis	*Monolepis nuttalliana*
Pale bastard toadflax	*Comandra umbellata*
Patogonia indianwheat	*Plantago patagonica*
Pepperweed	*Lepidium* spp.
Perenial flax	*Linum perenne*
Perenial ragweed	*Ambrosia psilostachya*
*Phlox	*Phlox* spp.

FORBS (continued)

Prairie coneflower	*Ratibida columnifera*
Prairie groundsel	*Senecio plattensis*
Prairiesmoke	*Geum trifolium*
Prairie sunflower	*Helianthus petiolaris*
Prickly poppy	*Argemone intermedia*
Prostrate knotweed	*Polygonum aviculare*
Purple coneflower	*Echinacea pallida*
Purple prairie clover	*Petalostemon purpureum*
Pussytoes	*Antennaria* spp.
Rag sumpweed	*Hymenopappus filifolius*
Red kitten-tail	*Besseya rubra*
Rock cress	*Arabis* spp.
Rush skeletonweed	*Lygodesmia juncea*
*Russian thistle	*Salsola kali*
Sainfoin	*Onobrychis viciaefolia*
Salsify	*Tragopogon* spp.
Scarlet gaura	*Gaura coccinea*
Scarlet globemallow	*Sphaeralcea coccinea*
Sego lily	*Calochortus* spp.

FORBS (continued)

Showy milkweed	*Asclepias speciosa*
Shrubby evening primrose	*Oenothera serrulata*
Silverleaf phacelia	*Phacelia hastata*
Silverleaf scurfpea	*Psoralea argophylla*
Slimflower scurfpea	*Psoralea tenuiflora*
Small-leaf pussytoes	*Antennaria parvifolia*
Spiny goldenweed	*Haplopappus spinulosus*
*Spotted knapweed	*Centaurea maculosa*
Spreading fleabane	*Erigeron* spp.
Starry false Solomon's seal	*Smilacina stellata*
Stemless flax	*Linum rigidum*
Stemless goldenweed	*Haplopappus acaulis*
*Stinkweed	*Hackelia deflexa*
Stiff goldenrod	*Solidago rigida*
Stiff sunflower	*Helianthus laetiflorus*
Stinging nettle	*Urtica dioica*
Sun spurge	*Euphorbia helioscopia*
Sweetscented bedstraw	*Galium triflorum*
Tarragon sagewort	*Artemisia dracunculus*

FORBS (continued)

Ten-petal blazing star	Mentzelia decapetala
Textile onion	Allium textile
Threeleaved milkvetch	Astragalus gilviflorus
Townsendia	Townsendia exscapa
Tufted broomrape	Orobanche fasciculata
Tufted milkvetch	Astragalus spatulatus
Tumble mustard	Sisymbrium altissimum
Vetch	Vicia sativa
Wavyleaf thistle	Cirsium undulatum
Waxleaf penstemon	Penstemon nitidus
Western aster	Aster occidentalis
White milkwort	Polygala alba
White sweetclover	Melilotus alba
*White top	Cardaria draba
Wild buckwheat	Eriogonum annuum
Wild licorice	Glycyrrhiza lepidota
Wild onion	Allium cernuum
Wild parsley	Musincon divaricatum
Woolly groundsel	Senecio canus

FORBS (continued)

Yarrow	*Achillea millefolium*
Yellow buckwheat	*Eriogonum flavum*
Yellow owlclover	*Orthocarpus luteus*
Yellow sweetclover	*Melilotus officinalis*
(no common name)	*Alyssum desertorum*
"	*Arnica fulgens*
"	*Brickellia oblongifolia*
"	*Cirsium flodmanii*
"	*Erigeron ochroleucus*
"	*Erigeron pumilus*
"	*Erigeron strigosus*
"	*Eriogonum pauciflorum*
"	*Evolvoidus nuttalliianus*
"	*Lactuca serriola*
"	*Lomatium foeniculaceum*
"	*Lomatium macrocarpum*
"	*Machaeranthera grindelioides*
"	*Phlox alsyssifolia*

APPENDIX D3

VEGETATION TYPE	No. 1 Douglas Fir	No. 2 Eastern Ponderosa Pine	No. 3 Ponderosa Pine Savanna	No. 4 Cottonwood-Willow
Associated Species Trees	‡Ponderosa pine ‡Lodgepole pine **Limber pine Quaking aspen	Rocky Mountain juniper Horizontal juniper	Rocky Mountain juniper	
Shrubs	Oregon grape Fringed sage Western snowberry Big sagebrush Dwarf huckleberry Hawthorn	*Skunkbush sumac Western snowberry Fringed sage Silver sagebrush Soapweed	*Skunkbush sumac Western snowberry Silver sagebrush Broom snakeweed Fringed sage Soapweed ‡Rose	‡Rose Buffaloberry Western snowberry Chokecherry ‡Serviceberry
Grasses	Rough fescue Pine reedgrass Bluebunch wheatgrass Idaho fescue Elk sedge	Bluebunch wheatgrass Needle & thread Blue grama †Western wheatgrass Green needlegrass *Prairie junegrass Side-oats grama Little bluestem	Bluebunch wheatgrass †Western wheatgrass Blue grama Native bluegrass Needle and thread Green needlegrass Threadleaf sedge Red three-awn Side-oats grama *Prairie junegrass Little bluestem	Sedges Wirerush
Forbs	Arrowleaf balsamroot Heartleaf arnica False Solomon's seal Bluebell Low larkspur Lupine	Phlox Arrowleaf balsamroot Silverleaf scurfpea Bluebell	Phlox Lupine Prairie coneflower Silverleaf scurfpea	‡Lambsquarter goosefoot Stinkweed
Geographic Area(s)	eastern Montana	eastern Montana	eastern Montana	eastern Montana
Topography	mountains	rough, broken land along the Yellowstone River, and rocky hills rising from plains	rolling to hilly on breaks and terraces	bottom land; river and creek bottoms
Elevation (ft) (MSL)	3,000 - 7,900'	3,000 - 4,500'	3,000 - 4,000'	3,100 - 6,000'
Exposure	northerly	variable denser stands on north and east slopes	south slopes, ridge tops, and swales	variable
Precipitation Zone(annual)	20-30"	10-18"	12-14"	14-20"
Soils	deep, porous soils; gravelly, sandy, or loamy	rocky-gravelly; poorly developed	stony and gravelly to loams and alluvium	gravelly, sandy; rich humus; some clay soils
Major Resource Uses	watershed; recreation; wildlife; timber	range, wildlife, watershed, timber	watershed, range, wildlife	streambank stabilization, wildlife
Remarks	aspen on the moister sites			severe impacts

VEGETATION TYPE	No. 5 ‡Boxelder-Green Ash-Rose-Chokecherry	No. 6 Big Sagebrush-Western Wheatgrass	No. 7 Big Sagebrush-Western Wheatgrass-Grama	No. 8 Big Sagebrush-Western Wheatgrass-Needle and Thread-Grama
Associated Species Trees				
Shrubs	Buffaloberry Silver sagebrush Western snowberry ‡Serviceberry	Broom snakeweed Pricklypear Silver sagebrush Soapweed	Pricklypear Fringed sage Silver sagebrush Soapweed	Fringed sage Pricklypear Soapweed
Grasses	Sedges **Bluegrass	Fringed sage Prairie junegrass Prairie sandreed Green needlegrass	*Prairie junegrass Prairie sandreed Threadleaf sedge Plains muhly	Native bluegrass *Prairie junegrass Plains reedgrass Threadleaf sedge Plains muhly
Forbs	**Burdock *Lambsquarter goosefoot Sweetscented bedstraw	*Vetch Wild onion	Clubmoss ‡Wild buckwheat	‡Wild buckwheat Phlox Scarlet globemallow
Geographic Area(s)	eastern Montana	eastern Montana	eastern Montana	eastern Montana
Topography	bottom land; river and creek bottoms	swales	foothills; plains	foothills; plains
Elevation (ft) (MSL)	3,100 - 4,500'	3,100 - 4,500'	3,100 - 4,200'	3,100 - 4,200'
Exposure	variable	flat to southerly	flat to southerly	west and south
Precipitation Zone(annual)	10-14"	12-16"	12-16"	12-16"
Soils	gravelly, sandy; rich humus	clay to clay loam in "B" horizon	loamy	silty to sandy loams
Major Resource Uses	streambank stabilization, wildlife	watershed, range, wildlife	watershed, range, wildlife	watershed, range, wildlife
Remarks	severe impacts	Western wheatgrass is an accumulator of selenium	Blue grama increases with heavy grazing; western wheatgrass is a selenium accumulator	Blue grama increases with heavy grazing; western wheatgrass is a selenium accumulator

VEGETATION TYPE	No. 9 Big Sagebrush-Grass	No. 10 Silver Sagebrush-Greasewood	No. 11 Bluebunch Wheatgrass-Fescue	No. 12 Western Wheatgrass-Needle and Thread-Green Needlegrass
Associated Species Trees			Horizontal juniper	
Shrubs	Rubber rabbitbrush Fringed sage Pricklypear Broom snakeweed	Shadscale saltbush Nuttall saltbush ‡Rose Big sagebrush	Shrubby cinquefoil Big sagebrush Fringed sage *Skunkbush sumac	Fringed sage Big sagebrush Pricklypear Soapweed Broom snakeweed
Grasses	Native bluegrass *Prairie junegrass Blue grama Bluebunch wheatgrass Idaho fescue Plains muhly Needle and thread	Needle and thread Saltgrass †Western wheatgrass Alkali bluegrass Basin wildrye Buffalograss Blue grama Red three-awn Greenneedle grass	†Western wheatgrass *Prairie junegrass Threadleaf sedge Needle and thread *Kentucky bluegrass Side-oats grama Parry oatgrass Richardsons needlegrass Timber oatgrass	*Prairie junegrass Threadleaf sedge Canada bluegrass Blue grama Native bluegrass Red three-awn Prairie sandreed
Forbs	Pussytoes Phlox Locoweed Lupine	Wild licorice Clubmoss Silverleaf scurfpea Cudweed sagewort	Lupine Yarrow Wild onion Arrowleaf balsamroot	Lupine Clubmoss Yarrow Silverleaf scurfpea Phlox
Geographic Area(s)	eastern Montana	eastern Montana	eastern Montana	eastern Montana
Topography	foothills	creek bottoms; rolling foothills	rolling hills	gently sloping to rolling
Elevation (ft) (MSL)	3,100 - 4,000'	3,100 - 4,000'	2,600 - 6,000'	3,000 - 4,800'
Exposure	south	variable	bluebunch dominant on south and southwest slopes; fescue on north and east	variable
Precipitation Zone(annual)	10-14"	10-14"	10-20"	10-20"
Soils	shaley soils; clay loam	clay loam, silt loam, sometimes sandy loam; alkaline	shallow, sandy to gravelly loams; rocky	shales, and where there is clay or clay loam in "B" horizon
Major Resource Uses	watershed, range wildlife	watershed, wildlife, range	range, watershed, wildlife	range, wildlife, watershed
Remarks		Dominance depends on salinity and depth of moisture.	With increased elevation, the fescues assume dominance, and bluebunch is uncommon.	

VEGETATION TYPE	No. 13 Needle and Thread-Western Wheatgrass-Grama	No. 14 Western Wheatgrass-Needle and Thread-Grama	No. 15 Grama-Western Wheatgrass-Needle and Thread	No. 16 Badlands
Associated Species Trees				Rocky Mountain juniper ‡Ponderosa pine
Shrubs	Silver sagebrush Broom snakeweed Pricklypear Big sagebrush Winterfat Fringed sage Soapweed	Big sagebrush Pricklypear Silver sagebrush Fringed sage Saltbush	Big sagebrush Fringed sage Greasewood Pricklypear Broom snakeweed	Greasewood Nuttall saltbush Fringed sage Big sagebrush Winterfat Shadscale saltbush
Grasses	Threadleaf sedge Native bluegrass *Prairie junegrass Plains reedgrass Bluebunch wheatgrass Needleleaf sedge Red three-awn *Indian ricegrass Green needlegrass Tumblegrass	Native bluegrass Green needlegrass *Prairie junegrass Plains reedgrass Plains muhly Threadleaf sedge Bluebunch wheatgrass Squirreltail	Buffalograss *Prairie junegrass Threadleaf sedge Red three-awn •Bluegrass Cheatgrass Bluebunch wheatgrass	*Alkali sacaton *Squirreltail Bluebunch wheatgrass *Indian ricegrass Little bluestem Blue grama Buffalograss Tumblegrass Prairie sandreed †Western wheatgrass Red three-awn
Forbs	**Scarlet globemallow Stinkweed Silverleaf scurfpea Lambsquarter goosefoot Phlox	Phlox ‡Wild buckwheat **Scarlet globemallow Spreading fleabane	Prairie coneflower Yarrow Silverleaf scurfpea	Silverleaf scurfpea Russian thistle Hoods phlox
Geographic Area(s)	eastern Montana	eastern Montana	eastern Montana	eastern Montana
Topography	rolling hills	plains to rolling and rough	plains to rolling	rough breaks
Elevation (ft) (MSL)	3,600 - 5,000'	3,000 - 4,800'	3,000 - 4,800'	3,000 - 4,000'
Exposure	variable	variable	variable	variable
Precipitation Zone(annual)	10-14"	10-14"	10-20"	10-14"
Soils	silty to sandy loams in A and B horizons	shales and where there is clay or clay loam in B horizon; heavy soils; sandy to gravelly	fine—to medium—textured; sands to clays; Needle & Thread occurring on coarse—to medium—textured	shaley clay
Major Resource Uses	Range, wildlife, watershed	range, wildlife, watershed	range, wildlife, watershed	wildlife, limited grazing, [illegible]
Remarks	Grama is an indicator of overgrazing	big sagebrush throughout in minor quantities		sensitive to disturbance, vegetation sparse

*known to be sensitive to SO_2 (Finklea 1973)
**known to be sensitive to Florides (Stern et al. 1973)
†known accumulator of selenium
‡known to be sensitive to both SO_2 and Florides
•known to be sensitive to NO_2 (Stern et al. 1973)

ENVIRONMENTAL RELATIONSHIPS OF VEGETATION TYPES WITHIN THE STUDY AREA

APPENDIX E: Radiation

E1 Sampling Site Locations

The following lists give the radiation sampling site locations for water, soil and vegetation. The sites are graphically shown on the locator maps included in Section 10.1.8. under each parameter.

Water Sampling Locations

Ground Seepage Water

Sample No.	Location
1	Western Energy Company Pit #6
2	Western Energy Company Pit #6
8	Mine pit approximately 1 mile north of Western Energy Company Pit #6
18	Pit located approximately 2 miles east of Colstrip
19	Pit located approximately 3½ miles east of Colstrip
89	Pit located approximately 1½ miles south of Colstrip

Spring Water

Sample No.	Location
4	Tom Wimer Ranch
12	C. K. Streeter Ranch (spring below house)
50	Cornwell Ranch
82	Egan Ranch
83	Greenleaf Land and Livestock Company
88	Spring located 9 miles west of Colstrip
91	Gillin Ranch (1½ miles south of ranch house)
92	Gillin Ranch (1½ miles northeast of ranch house)
93	Gillin Ranch (north of ranch house)
99	H. Sprague Ranch

Creek Water

Sample No.	Location
6	East Armell's Creek (opposite power plant)
15	East Armell's Creek (8 miles north of Colstrip)
17	East Armell's Creek (2 miles north of Colstrip)
28	Rosebud Creek (2 miles west of Rocker Six Cattle Co.)
43	Rosebud Creek (Frank Lange ranch)
46	Rosebud Creek (9 miles south of Colstrip)
49	Rosebud Creek (Cornwell ranch)
71	East Armell's Creek (Interstate 94 crossing)

Well Water

Sample No.	Location
3	Tom Wimer Ranch (house well), depth approximately 130 ft.
5	Tom Wimer Ranch (garden plot well)
7	Trailer No. 104, Colstrip
9	Stock watering well located approximately 6 miles southeast of Colstrip
10	B & R Bar and Cafe
11	C. K. Streeter Ranch (house well), depth 18 - 20 feet.
13	McDonald Ranch, depth 100 - 110 feet
14	C. K. Streeter Ranch (stock water), depth approximately 100 feet
16	Stock watering well 2.5 miles north of Colstrip
20	Trailer court located 5 miles south of Colstrip and about 1 mile west of Highway 315 (drinking water), depth approximately 400 feet
21	Trailer court located 5 miles south of Colstrip and about 1 miles west of Highway 315 (irrigating water), depth of approximately 200 feet

Sample No.	Location
22	Jim Snider Ranch (drinking water), depth approximately 240 feet
23	Jim Snider Ranch (yard well)
24	McRae Ranch (drinking water)
25	Lee E. Cartwright (drinking water), depth approximately 200 feet
26	Lee E. Cartwright (stock watering well)
27	Rocker Six Cattle Co. (yard well), depth approximately 40 feet
29	Joe W. Curran Ranch (drinking water)
30	G. Peters place
31	Sprague Farm, depth approximately 180 feet
32	Bill Groom Farm (drinking water), depth 78 feet
33	Kluver Ranch (barn well), depth 80 feet
34	Kluver Ranch (front yard well), approximately 300 feet
35	Kluver Ranch property (stock watering well), depth approximately 80 feet
36	Mac Philbrick Diamond Ranch (yard well)
37	Mac Philbrick Diamond Ranch (stock watering well)

Sample No.	Location
38	Joe Egan Ranch, depth 150 feet
39	Cornwell Ranch (drinking water), depth 70 feet
40	Cornwell Ranch (stock watering well), depth 81 feet
41	Frank Lange Ranch (drinking water), depth approximately 120 feet
42	Frank Lange Ranch, depth 40 feet
44	Ringer Farm (drinking water), depth approximately 160 feet
45	Philbrick Ranch (stock watering well)
47	Cornwell Ranch (Cherry Creek Well), depth 205 feet
48	Cornwell Ranch (automatic well), depth 390 feet
51	Hanna Ranch (house well), depth 90 feet
52	Hanna Ranch (stock watering well), depth 30 feet
53	Joe Egan Ranch (drinking water), depth approximately 240 feet
54	Leo Farley Ranch (drinking water)
55	Lee Ranch (stock watering well), depth 160 feet
56	Lee Ranch (stock watering well), depth 121 feet
57	Kozelka Farm, depth 30 feet

Sample No.	Location
58	Kozelka Farm, depth 150 feet
59	Gillin Ranch (drinking water), depth 125 feet
60	L. Ranch (stock and yard watering well), depth 40 feet
61	L. Ranch (drinking water), depth 550 feet
62	L. Ranch (stock watering well), depth 200 feet
63	Sloan Ranch (house water), depth approximately 200 feet
64	Sloan Ranch (stock watering well)
65	Don Snider Ranch (drinking water), depth 190 feet
66	Don Snider Ranch (stock watering well), 2 miles north of Castle Rock, depth 150 feet
67	Don Snider Ranch (stock watering well)
68	R. H. Huston Ranch (yard well), depth approximately 121 feet
69	Ashenhurst Ranch (drinking water), depth 30 feet
70	Ashenhurst Ranch (yard well), depth 30-40 feet
72	Stock watering well, 7 miles south of Colstrip
73	Don Bailey Ranch (drinking water), depth approximately 270 feet
74	Jim Bailey Ranch (drinking water), depth 263 feet
75	Broadus Ranch (lower house)

Sample No.	Location
76	Broadus Ranch (upper house)
77	Davidson Ranch (drinking water), depth 190 feet
78	Morningstar Lodge and Cafe, depth 200 feet
79	John Bailey Ranch (drinking water), depth 221 feet
80	Egan Ranch (drinking water)
81	Egan Ranch (grey stucco and log house)
84	Fahdl Ranch (drinking water), depth 40 feet
85	Fahdl Ranch (stock watering well), depth 210 feet
86	Stock watering well located 8 miles west of Colstrip
87	Well located 9 miles west of Colstrip
90	Stock watering well 1½ miles south of Colstrip
94	Gillin Ranch (stock watering well), depth 20 feet
95	Stock watering well 4 miles south of intersection of West Fork Armell's Creek Road and Highway 315
96	L. Frieze Ranch (drinking water), depth 125 feet
97	L. Frieze Ranch (stock watering well)
98	H. Sprague Ranch (house well), depth 135 feet

Sample No.	Location
100	McRae Ranch (house water)
101	Mobley Ranch (house water), depth 500-800 feet
102	Mobley Ranch (stock watering well in corral), depth 20-30 feet
103	McRae Ranch (stock watering well)
104	Les Coates Ranch (stock watering well), depth 46 feet
105	Les Coates Ranch (stock watering well), depth 80 feet
106	Les Coates Ranch (yard well), depth 200 feet
107	McRae Ranch (stock watering well)
108	McRae Ranch (stock watering well)
109	McRae Ranch (stock watering well)
110	Ranch 5½ miles south of Interstate 94 on Highway 315
111	Stock watering well 3 miles south of Colstrip on Highway 315

Soil Sampling Sites

Site	Location	
N-1	T2N R41E	SE¼ Sec. 16
N-2	T2N R41E	NE¼ Sec. 28
N-3	T5N R41E	NE¼ Sec. 16
N-4	T8N R40E	SE¼ Sec. 36
NE-1	T2N R41E	SW¼ Sec. 24
NE-2	T3N R42E	SW¼ Sec. 36
NE-3	T4N R43E	NE¼ Sec. 10
NE-4	T6N R48E	NW¼ Sec. 8
E-1	T2N R41E	SE¼ Sec. 25
E-2	T2N R43E	NW¼ Sec. 31
E-3	T2N R44E	NE¼ Sec. 27
E-4	T2N R47E	NE¼ Sec. 36
SE-1	T1N R42E	NW¼ Sec. 16
SE-2	T1S R42E	SW¼ Sec. 1
SE-3	T2S R44E	N½ Sec. 17
SE-4	T4S R46E	NW¼ Sec. 26

Site	Location	
S-1	T1N R41E	SE¼ Sec. 36
S-2	T1S R41E	SE¼ Sec. 36
S-3	T2S R41E	NE¼ Sec. 12
S-4	T2S R41E	SW¼ Sec. 25
SW-1	T1N R41E	NE¼ Sec. 33
SW-3	T2S R44E	N½ Sec. 17
W-1	T2N R40E	SE¼ Sec. 36
W-2	T2N R39E	Center Sec. 36
W-3	T2N R37E	SW¼ Sec. 36
W-4	T2N R35E	NE¼ Sec. 8
NW-1	T3N R40E	SW¼ Sec. 36
NW-2	T3N R39E	Center Sec. 36
NW-3	T4N R39E	NE¼ Sec. 16
NW-4	T5N R36E	SW¼ Sec. 2
NW-5	T10N R32E	SE¼ Sec. 28
TR-1	T1S R44E	SE¼ Sec. 16
TR-2	T1S R44E	SE¼ Sec. 16
TR-3	T1N R44E	N½ Sec. 14
TR-4	T1N R44E	N½ Sec. 14
TR-5	T1N R44E	N½ Sec. 14

Site	Location	
TR-6	T1N R44E	N½ Sec. 27
TR-7	T1N R44E	N½ Sec. 27
TR-8	T1N R44E	N½ Sec. 27
TR-9	T1N R44E	N½ Sec. 27
TR-10	T1N R44E	N½ Sec. 27
TR-11	T1N R44E	N½ Sec. 14
TR-12	T1N R44E	N½ Sec. 14
TR-13	T1N R44E	Center Sec. 14
TR-14	T1N R44E	Center Sec. 14
TR-15	T1N R44E	Center Sec. 14
TR-16	T1N R44E	Center Sec. 14
TR-17	T1N R44E	Center Sec. 14
TR-18	T1N R44E	Center Sec. 14
TR-20	T1N R44E	Center Sec. 14
A-1	T5N R39E	SW¼ Sec. 2
A-2	T3N R40E	SW¼ Sec. 6
A-3	T2N R39E	SW¼ Sec. 13
A-4	T1N R40E	SW¼ Sec. 9
A-5	T1N R43E	NE¼ Sec. 17
A-6	T4N R43E	SW¼ Sec. 32

Site	Location	
A-7	T5N R42E	SW¼ Sec. 8
A-8	T2S R44E	NW¼ Sec. 22
A-9	T1N R44E	SE¼ Sec. 1
A-10	T6N R46E	SE¼ Sec. 31

Vegetation Sampling Sites

Site	Location	
N-1	T2N R41E	SE¼ Sec. 16
N-2	T3N R41E	Center Sec. 16
N-3	T5N R41E	NE¼ Sec. 16
N-4	T8N R40E	SE¼ Sec. 36
NE-1	T2N R42E	Center Sec. 16
NE-2	T3N R42E	SW¼ Sec. 36
NE-3	T4N R43E	NE¼ Sec. 10
NE-4	T6N R46E	SE¼ Sec. 17
E-1	T2N R42E	SE¼ Sec. 29

Site	Location	
E-2	T2N R43E	NW¼ Sec. 31
E-3	T2N R44E	NE¼ Sec. 27
E-4	T2N R47E	NE¼ Sec. 36
E-5	T2S R55E	NW¼ Sec. 18
SE-1	T1N R42E	NW¼ Sec. 16
SE-2	T1S R42E	SW¼ Sec. 1
SE-3	T2S R44E	N½ Sec. 17
SE-4	T4S R46E	NW¼ Sec. 26
SE-5	T9S R50E	SE¼ Sec. 12
S-1	T1N R41E	SE¼ Sec. 36
S-2	T1S R41E	SE¼ Sec. 36
S-3	T2S R41E	NE¼ Sec. 12
S-4	T2S R41E	NE¼ Sec. 25
SW-1	T1N R40E	SE¼ Sec. 36
SW-2	T1N R39E	NE¼ Sec. 36
SW-3	T2S R38E	SW¼ Sec. 13
SW-4	T3S R35E	NW¼ Sec. 20
W-1	T2N R40E	SE¼ Sec. 36
W-2	T2N R39E	Center Sec. 36
W-3	T2N R37E	SW¼ Sec. 36

Site	Location	
W-4	T2N R35E	NE¼ Sec. 8
NW-1	T3N R40E	SW¼ Sec. 36
NW-2	T3N R39E	Center Sec. 36
NW-3	T4N R39E	NE¼ Sec. 16
NW-4	T5N R36E	SW¼ Sec. 2
A-1	T5N R39E	SW¼ Sec. 2
A-2	T3N R40E	SE¼ Sec. 6
A-3	T2N R39E	SW¼ Sec. 13
A-4	T1N R40E	SW¼ Sec. 9
A-5	T1N R43E	NE¼ Sec. 17
A-6	T4N R43E	SW¼ Sec. 32
A-7	T5N R42E	SE¼ Sec. 8
A-8	T2S R44E	NW¼ Sec. 22
A-9	T1N R44D	SE¼ Sec. 1
A-10	T6N R46E	SE¼ Sec. 31

E2 Sample Preparation and Analysis Techniques

Sample Preparation Techniques

1. Water

   a. Radium in Water

      1. Acidify water to be analyzed with approximately 5 ml of concentrated HNO_3 per liter.

      2. Withdraw a one liter sample.

      3. Filter sample through a 0.45 u filter and transfer the filtrate to a 1500 ml beaker.

      4. Add 3 ml of 1 M citric acid and stir.

      5. Add 2.5 ml of concentrated Nh_4OH.

      6. Add 2 ml of Pb carrier solution (1 ml=100 mg Pb).

      7. Ba carrier: add 10 ml of Ba stock solution to a 100 ml volumetric flask and dilute to volume. Add 10 ml of Ba carrier solution.

      8. Place on hot plate and add 10 drops of methyl orange indicator.

      9. Add 5½ ml of 1:1 H_2SO_4 and stir.

      10. Heat to about 80^oC, remove stirring rods and cover beakers.

      11. Remove from heat and let settle overnight.

      12. Remove supernatant with an aspirator until only about 10 ml of solution remains.

      13. Using water, transfer the precipitate to a 50 ml centrifuge tube and centrifuge for 5-10 minutes.

14. Decant and discard supernatant.

15. Add 10 ml concentrated HNO_3.

16. Break up precipitate with glass stirring rods and stirring rods and stir.

17. Centrifuge for 5-10 minutes.

18. Decant and discard supernatant.

19. Repeat steps 15-18.

20. Add 15 ml H_2O and 2 drops of phenolpthalein solution.

21. Titrate with 5M NH_4OH to the phenolphthalein end point.

22. Add 10 ml of EDTA solution and 3 ml of 5M NH_4OH.

23. Heat in a hot water bath until the precipitate can be dissolved by stirring.

24. Remove from heat and add 6 drops of bromocresol green indicator.

25. Tritrate with glacial acetic acid to the bromocresol green end point (pH=4.2).

26. Record date and time of day (count in 21 days for Ra-226).

27. Rinse and remove stirring rods, dilute to equal volumes and let stand for at least 10 minutes.

28. Centrifuge for 5-10 minutes.

29. Decant and discard supernatant.

30. Add 20 ml of H_2O using a water jet to break up the precipitate.

31. Centrifuge 5-10 minutes.

32. Decant and discard supernatant.

33. Repeat steps 30-32.

34. Wash down sides of tube with 3-4 ml of water.

35. Add 1½ ml of absolute ethanol.

36. Scrape the walls of the tube and break up the precipitate with a pointed stirring rod.

37. Rinse rod and transfer the precipitate into a pre-weighed stainless steel planchet with water.

38. Let the planchet sit until dry (can use heat lamp).

39. Dessicate to constant weight and weigh.

b. Gross alpha and gross beta in water.

1. Place a 100 ml sample in a 250 ml beaker (solids must be less than 0.4 g).

2. Add 4 ml of 1% HNO_3.

3. Evaporate on hot plate until only about 5 ml of solution remains.

4. Transfer the solution to a pre-weighed planchet with water.

5. Let the planchet sit until dry.

6. Dessicate to a constant weight and weigh.

2. Soil

a. Gross alpha and beta

1. Dry several grams of sample in an over at 100^{o}C for several hours.

2. Pass the dried sample through a number 200 standard sieve (nominal opening 0.0029 inches).

3. Cone and quarter the sieved sample and discard alternate quarters.

4. Continue coning and quartering until approximately one gram of sample remains.

5. Place about 0.2 gram of sample into a small beaker.

6. Add 10 ml of water and mix well.

7. Transfer the mixture into a preweighed stainless steel planchet with water.

8. Let the planchet sit until dry.

9. Dessicate to constant weight and weigh.

3. Vegetation

a. Gross alpha and beta

1. Air dry sample at $90^{o}F$ in a forced draft furnace.

2. Grind to pass through a number 40 mesh screen.

3. Place 5 grams of sample in an inconel crucible.

4. Heat in a muffle furnace to $600^{o}C$ and continue heating at this temperature until only a white ash remains.

5. Remove sample from furnace and allow to cool.

6. Transfer the ash with water to a preweighed stainless steel planchet.

4. Air

From each 8 inch by 10 inch fiberglass filter, cut a circuluar sample

having a diameter of 4.2 cm. Transcribe the filter serial number on the sample for identification. The sample is ready for counting in the low background alpha-beta counter.

Sample Analysis Techniques

1. Water

a. Gross Alpha and Beta

The stainless steel planchets containing the water samples, prepared as described above, were counted for 50 minutes for both alpha and beta in a Beckman Wide Beta II counting system. The Wide Beta II System is a low-background, thin-window, gas-flow proportional counter.

The gross alpha activity was calculated using the following relationship:

$\alpha pCi/l=(\alpha_S-\alpha_B)(DTCF)\alpha V_S$

Where $\alpha pCi/l$=gross alpha activity in picocuries per liter (pCi/l).

α_S=alpha counting rate of the sample in counts per minute (cpm)

α_B=alpha background counting rate in cpm which was monitored daily

$(DTCF)\alpha$=alpha density thickness correction factor in picocuries per count per minute (pCi/cpm) obtained from calibration curves prepared from a natural uranium standard

V_S= the sample volume correction factor (1)/(sample volume in liters)

The gross beta activity was obtained from the following relationship:

$^{\beta}pCi/l=(\beta_S-\beta_S-C\alpha_S)(DTCF)\beta V_S$

Where $\beta pCi/l$= gross beta activity in picocuries per liter (pCi/l)

β_S= beta counting rate of the sample in cpm

β_B= beta background counting rate in cpm which was monitored daily

α_S= alpha counting rate of the sample (cpm)

C = alpha cross-talk fraction

$(DTCF)\beta$= beta density thickness correction factor in picocuries per count per minutes (pCi/cpm) obtained from calibration curves which were developed using a cesium-137 standard.

V_S= the sample volume correction factor = (1)/(sample volume in liters)

b. Radium-226

The planchets prepared as described in part C.a.1., of this section were counted for 50 minutes for alpha in the Beckman Wide Beta II proportional counter. The radium activity was then calculated from the following relationship:

$$A_R\alpha=(\alpha_S-\alpha_B)(DTCF)_{R\alpha}V_S$$

Where $A_{R\alpha}$= the radium-226 activity in picocuries per liter

α_S= alpha counting rate of the sample (cpm)

α_B= alpha background counting rate (cpm)

$(DTCF)_{R\alpha}$= The radium density thickness correction factor in picocuries per count per minute obtained from calibration curves which were developed using a radium-226 standard.

V_S= volume correction factor = (1)/(sample volume in liters)

2. Soil

a. Gross alpha and beta

The sample analysis procedure for gross alpha and beta activity in soil is

the same as those procedures described for the water samples except that activity is calculated in picocuries per gram and a mass correction factor replaces the volume correction factor.

3. Vegetation

a. Gross alpha and beta

The analysis procedure used for the vegetation samples is identical to that for the water samples except that activity is reported in picocuries per gram of ash and a mass correction factor is used instead of the volume correction factor.

4. Air

Air samples are aged for 15 days after collection prior to counting. This aging period allows the short-lived radon and thoron daughters to decay, leaving the sample activity relatively stable.

Gross beta activity is counted for 50 minutes in a Beckman Wide Beta II low-background counter. The efficiency of this counter is calibrated daily with a strontium-90 calibration source of known activity.

The gross beta activity of the air filter samples is computed in the following manner:

Gross beta activity

$$\frac{(C)\ (A_1)}{(E)\ (A_2)\ (V)\ (T)\ (2.2\ \text{dpm/pCi})}\quad \text{pCi/m}^3$$

A_1 = effective area of filtration of fiberglass filter 434 cm^2

A_2 = area of sample 13.85 cm^2

C = net count (background subtracted)

V = volume in cubic meters of air passed through filter.

E = counting efficiency of low-background counter

T = counting time in minutes

E3: Results of Radiation Sampling

TABLE 1

Gross Beta, Gross Alpha and Radium-226 Activity in Ground Seepage Waters

Sample No.	Gross Beta (pCi/1)	Gross Alpha (pCi/1)	Ra-226 (pCi/1)
1	9.31	<0.56	0.63
2	2.37	2.76	0.36
8	9.75	<2.12	0.28
18	39.37	12.91	<0.10
19	43.50	16.98	<0.10
89	28.37	<3.83	<0.10

TABLE 2

Gross Beta, Gross Alpha and Radium-226
Activity in Spring Waters

Sample No.	Gross Beta (pCi/1)	Gross Alpha (pCi/1)	Radium-226 (pCi/1)
4	4.23	<0.87	0.21
12	4.82	0.76	0.25
50	22.95	5.09	<0.10
82	<1.48	<0.80	<0.10
83	3.00	<0.90	<0.10
88	12.12	<0.93	0.18
91	16.51	5.00	<0.10
92	24.43	32.12	<0.10
93	12.89	<4.60	<0.10
99	6.07	<1.37	0.11

TABLE 3

Gross Beta, Gross Alpha and Radium-226
Activity in Creek Waters

Sample No.	Gross Beta (pCi/1)	Gross Alpha (pCi/1)	Radium-226 (pCi/1)
6	26.89	<1.56	<0.10
15	32.82	19.69	<0.10
17	10.01	<2.43	0.96
28	23.53	<1.64	<0.10
43	9.19	6.03	0.16
46	8.68	1.04	<0.10
49	9.62	0.99	0.17
71	12.36	1.80	0.16

TABLE 4

Gross Beta, Gross Alpha and Radium-226
Activity in Well Waters

Sample No.	Gross Beta (pCi/l)	Gross Alpha (pCi/l)	Radium-226 (pCi/l)
3	14.81	7.09	0.45
5	6.54	1.52	0.31
7	15.82	14.73	6.79
9	16.34	<2.14	<0.10
10	16.34	<1.91	0.89
11	5.42	5.11	1.11
12	4.82	0.76	0.25
13	12.11	7.51	0.43
14	5.39	<1.25	0.19
16	3.31	<0.97	<0.10
20	<1.64	1.37	0.15
21	<1.62	<1.24	0.49
22	<1.56	4.25	0.21
23	<1.53	<0.97	0.13

Table 4 (continued)

Gross Beta, Gross Alpha and Radium-226
Activity in Well Waters

Sample No.	Gross Beta (pCi/l)	Gross Alpha (pCi/l)	Radium-226 (pCi/l)
24	4.81	3.75	0.29
25	7.04	<1.27	0.34
26	12.51	<1.77	<0.10
27	13.27	<1.82	0.57
29	15.31	<1.96	0.62
30	7.90	4.47	0.37
31	<1.51	<0.92	0.16
32	<1.53	1.00	0.20
33	15.11	<1.54	0.38
34	6.41	2.48	0.29
35	2.62	3.51	<0.10
36	<1.58	<1.14	0.18
37	2.79	2.98	0.22
38	15.12	<1.65	0.21
39	3.62	1.11	<0.10

Table 4 (continued)

Gross Beta, Gross Alpha and Radium-226
Activity in Well Waters

Sample No.	Gross Beta (pCi/l)	Gross Alpha (pCi/l)	Radium-226 (pCi/l)
40	5.91	5.99	0.28
41	4.88	<1.59	0.10
42	<3.26	<2.57	<0.10
44	<1.57	<1.09	<0.10
45	4.15	1.85	0.26
47	<1.59	<1.16	0.10
48	3.68	<1.13	0.25
51	6.73	<1.68	0.23
52	4.42	1.45	0.21
53	8.25	4.69	0.26
54	4.16	1.49	0.36
55	4.02	<1.58	<0.10
56	3.81	1.02	<0.10
57	9.23	<3.20	<0.10

Table 4 (continued)

Gross Beta, Gross Alpha and Radium-226
Activity in Well Waters

Sample No.	Gross Beta (pCi/l)	Gross Alpha (pCi/l)	Radium-226 (pCi/l)
58	10.67	4.09	<0.10
59	<1.72	1.66	0.14
60	<1.90	<2.02	0.23
61	<1.51	<0.92	<0.10
62	7.58	<1.66	0.16
63	16.73	9.87	0.44
64	26.49	19.70	<0.10
65	8.47	2.71	0.27
66	18.88	19.02	0.74
67	4.36	2.71	<0.10
68	4.14	<1.39	0.10
69	2.69	3.88	<0.10
70	<1.50	<0.89	0.23
72	11.96	1.75	0.41
73	3.27	2.73	0.79

Table 4 (continued)

Gross Beta, Gross Alpha and Radium-226
Activity in Well Waters

Sample No.	Gross Beta (pCi/l)	Gross Alpha (pCi/l)	Radium-226 (pCi/l)
74	4.11	<1.34	0.22
75	<1.56	<1.13	<0.10
76	<1.57	<1.11	<0.10
77	4.25	1.25	0.10
78	8.51	<1.18	0.13
79	2.26	2.88	0.22
80	<1.61	7.39	<0.10
81	1.61	1.31	<0.10
84	<1.44	<0.68	0.15
85	3.70	7.97	0.52
86	3.36	<1.46	0.20
87	<1.49	<0.85	<0.10
90	1.86	1.26	<0.10
94	14.27	15.83	<0.10

Table 4 (continued)

Gross Beta, Gross Alpha and Radium-226 Activity in Well Waters

Sample No.	Gross Beta (pCi/l)	Gross Alpha (pCi/l)	Radium-226 (pCi/l)
95	1.75	<0.89	<0.10
96	1.55	<1.04	<0.10
97	2.05	3.23	<0.10
98	4.18	<0.80	0.17
100	<1.65	<1.33	0.10
101	3.91	<1.09	0.14
102	20.98	6.37	<0.10
103	<1.59	7.65	0.36
104	3.13	<1.09	0.21
105	3.57	4.19	0.14
106	3.01	1.88	0.10
107	3.60	<1.12	<0.10
108	5.56	5.90	<0.10
109	7.51	2.17	0.27
110	<1.55	1.08	<0.10
111	6.58	3.21	0.22

TABLE 5

Gross Beta and Gross Alpha Activity in Soils

Sample No.	Gross Beta (pCi/g)	Gross Alpha (pCi/g)
N-1	38.40	15.39
N-2	32.87	13.10
N-3	35.85	12.95
N-4	30.52	10.35
NE-1	38.53	16.83
NE-2	26.34	14.55
NE-3	35.09	9.63
NE-4	32.40	9.72
E-1	40.61	17.28
E-2	36.84	9.13
E-3	38.08	14.47
E-4	35.09	8.33
SE-1	37.03	12.04
SE-2	34.23	12.11
SE-3	36.60	11.13
SE-4	34.67	10.07
S-1	35.74	11.97
S-2	33.55	19.13
S-3	43.01	17.64
S-4	38.51	14.50
SW-1	30.08	11.08
SW-3	37.28	16.70
W-1	34.71	8.25
W-2	45.47	15.81
W-3	45.97	19.54
W-4	31.30	6.21
NW-1	35.50	7.91
NW-2	32.95	8.26
NW-3	34.90	11.43
NW-4	29.60	20.53
NW-5	30.35	14.13
TR-1	28.17	10.78
TR-2	36.26	11.64
TR-3	32.42	13.16
TR-4	29.22	6.30
TR-5	33.22	14.42
TR-6	36.92	8.05
TR-7	39.18	14.47
TR-8	38.42	20.52
TR-9	33.98	15.25
TR-10	33.64	13.13
TR-11	29.51	5.02
TR-12	31.12	25.90
TR-13	33.15	22.39

TABLE 5 (Cont.)

Sample No.	Gross Beta (pCi/g)	Gross Alpha (pCi/g)
TR-14	29.61	12.50
TR-15	41.16	22.95
TR-16	39.44	27.31
TR-17	47.97	11.05
TR-18	28.73	12.04
TR-19	38.43	10.88
TR-20	30.54	13.67
A-1	32.64	10.52
A-2	36.72	9.33
A-3	34.27	11.88
A-4	37.30	12.14
A-5	28.38	13.87
A-6	39.04	14.28
A-7	31.12	15.93
A-8	28.43	10.67
A-9	29.98	13.25
A-10	33.44	14.02

TABLE 6

Gross Beta and Gross Alpha Activity in Vegetation Samples

Site	Sample Description	Gross Beta (pCi/g-ash)	Gross Alpha (PCi/g-ash)
N-1	Ponderosa Pine,[1] 1970	156.04	7.40
	1971	145.30	1.55
	1972	159.80	3.10
	1973	216.23	3.55
	Silver Sage[2]	278.26	3.22
	Little Bluestem[3]	165.26	16.43
N-2	Ponderosa Pine, 1970	162.34	3.59
	1971	163.96	2.27
	1972	192.45	10.14
	1973	233.59	3.32
	Big Sage[4]	332.75	1.30
	Bluebunch Wheatgrass[5]	108.96	12.78
N-3	Big Sage	347.49	3.85
	Bluebunch Wheatgrass	117.42	13.02
N-4	Ponderosa Pine, 1970	176.70	5.21
	1971	181.46	<2.25
	1972	159.56	0.77
	1973	215.73	2.37
	Bluebunch Wheatgrass	152.86	16.56
NE - 1	Ponderosa Pine, 1970	167.89	8.22
	1971	157.72	5.29
	1972	156.18	5.96
	1973	214.33	3.12
	Silver Sage	300.67	1.95
	Little Bluestem	163.27	15.00
NE - 2	Ponderosa Pine, 1970	180.53	3.70
	1971	163.28	5.94
	1972	165.02	10.37
	1973	218.09	0.82
	Little Bluestem	159.57	17.33
	Big Sage	367.87	3.25
NE - 3	Ponderosa Pine, 1970	166.43	7.55
	1971	182.54	6.82
	1972	165.62	6.80
	1973	201.05	1.59
	Rocky Mountain Juniper[6]	189.99	12.01
	Little Bluestem	142.49	33.73

TABLE 6

Site	Sample Description	Gross Beta (pCi/g-ash)	Gross Alpha (pCi/g-ash)
NE - 4	Bluebunch Wheatgrass	144.02	5.65
	Big Sage	329.89	3.25
E - 1	Ponderosa Pine, 1971	148.60	1.48
	1972	144.49	2.93
	1973	209.38	<2.31
	Bluebunch Wheatgrass	144.79	16.74
E - 2	Ponderosa Pine, 1970	160.17	4.53
	1971	170.99	4.48
	1972	161.02	5.99
	1973	221.45	9.39
	Rocky Mountain Juniper	169.75	11.28
	Bluebunch Wheatgrass	179.42	26.95
E - 3	Ponderosa Pine, 1970	176.30	6.48
	1971	124.60	1.91
	1972	172.53	5.11
	1973	216.51	1.61
	Little Bluestem	124.85	9.09
	Rocky Mountain Juniper	180.00	0.71
E - 4	Ponderosa Pine, 1970	170.32	3.68
	1971	184.62	9.50
	1972	172.75	4.51
	1973	210.74	<2.27
	Big Sage	349.86	2.57
	Little Bluestem	127.99	6.90
E - 5	Ponderosa Pine, 1970	197.00	25.53
	1971	176.10	5.98
	1972	196.54	2.33
	1973	241.11	5.64
	Rocky Mountain Juniper	185.07	3.26
	Bluebunch Wheatgrass	107.48	14.11
SE - 1	Ponderosa Pine, 1970	179.38	8.09
	1971	166.88	5.59
	1972	172.20	7.44
	1973	221.53	2.34
	Rocky Mountain Juniper	173.91	12.11
	Sand Grass	91.63	3.81
SE - 2	Ponderosa Pine, 1970	164.84	8.39
	1971	173.73	5.36
	1972	181.55	<2.22
	1973	203.00	1.57
	Silver Sage	304.78	3.15
	Little Bluestem	145.34	8.58

TABLE 6 (cont.)

Site	Sample Description	Gross Beta (pCi/g-ash)	Gross Alpha (pCi/g-ash)
SE - 3	Ponderosa Pine, 1970	191.51	9.70
	1971	192.13	7.54
	1972	189.78	0.76
	1973	234.12	1.55
	Skunkbush[8]	215.48	7.05
	Bluebunch Wheatgrass	68.28	9.26
SE - 4	Ponderosa Pine, 1970	164.68	12.07
	1971	147.62	3.08
	1972	141.98	4.53
	1973	232.05	<2.40
	Little Bluestem	171.71	6.42
	Skunkbush	157.88	2.63
SE - 5	Ponderosa Pine, 1970	230.01	24.30
	1971	221.77	10.74
	1972	180.46	10.55
	1973	255.22	3.22
	Little Bluestem	194.26	13.50
S - 1	Ponderosa Pine, 1970	146.12	4.55
	1971	175.48	4.64
	1972	183.65	6.92
	1973	228.99	0.85
	Little Bluestem	157.45	13.36
	Rocky Mountain Juniper	170.59	7.42
S - 2	Ponderosa Pine, 1970	199.56	8.22
	1971	203.74	5.94
	1972	217.73	6.54
	1973	252.88	1.56
	Rocky Mountain Juniper	283.72	5.17
	Bluebunch Wheatgrass	75.12	8.74
S - 3	Ponderosa Pine, 1970	255.33	14.76
	1971	163.73	6.74
	1972	167.24	2.29
	1973	238.63	6.08
	Skunkbush	259.88	2.61
	Bluebunch Wheatgrass	99.08	11.67
S - 4	Ponderosa Pine, 1970	134.26	< 2.23
	1971	147.09	2.28
	1972	137.69	2.23
	1973	251.23	13.07
	Big Sage	320.08	3.26
	Bluebunch Wheatgrass	67.87	6.86

TABLE 6 (cont.)

Site	Sample Description	Gross Beta (pCi/g-ash)	Gross Alpha (pCi/g-ash)
SW - 1	Ponderosa Pine, 1970	160.12	9.20
	1971	178.57	3.89
	1972	171.35	4.32
	1973	226.43	1.65
	Rocky Mountain Juniper	178.12	3.43
	Bluebunch Wheatgrass	126.31	7.62
SW - 2	Ponderosa Pine, 1970	184.12	5.89
	1971	195.82	5.10
	1972	211.09	3.66
	1973	239.26	2.30
	Rocky Mountain Juniper	190.43	5.39
	Bluebunch Wheatgrass	107.08	15.20
SW - 3	Ponderosa Pine, 1970	190.30	13.58
	1971	213.02	2.43
	1972	214.53	< 2.37
	1973	232.37	< 2.37
	Bluebunch Wheatgrass	154.71	17.28
	Common Rubber Rabbitbrush[9]	306.85	3.78
SW - 4	Big Sage	345.66	4.48
	Snowberry[10]	225.49	2.63
W - 1	Ponderosa Pine, 1970	181.00	3.89
	1971	192.03	3.85
	1972	164.61	0.83
	1973	207.52	3.99
	Silver Sage	282.74	3.16
	Little Bluestem	222.35	6.30
W - 2	Ponderosa Pine, 1970	185.80	< 2.40
	1971	197.64	10.93
	1972	221.63	3.92
	1973	253.03	7.05
	Little Bluestem	175.66	9.89
	Rocky Mountain Juniper	162.61	< 1.96
W - 3	Ponderosa Pine, 1970	174.99	12.05
	1971	168.52	6.45
	1972	175.14	10.57
	1973	231.68	5.44
	Rocky Mountain Juniper	212.50	5.27
	Bluebunch Wheatgrass	80.49	< 2.12

TABLE 6 (cont.)

Site	Sample Description	Gross Beta (pCi/g-ash)	Gross Alpha (pCi/g-Ash)
W - 4	Ponderosa Pine, 1970	169.71	4.42
	1971	188.47	3.85
	1972	191.84	1.56
	1973	222.94	8.59
	Silver Sage	259.82	0.66
	Little Bluestem	126.57	3.23
NW - 1	Ponderosa Pine, 1970	161.10	11.96
	1971	178.47	13.97
	1972	181.28	2.26
	1973	236.25	10.22
	Silver Sage	253.00	2.56
	Bluebunch Wheatgrass	111.19	6.42
NW - 2	Ponderosa Pine, 1970	166.79	3.01
	1971	174.66	6.47
	1972	171.23	3.00
	1973	205.26	1.58
	Common Rubber Rabbitbrush	292.90	1.31
	Bluebunch Wheatgrass	91.63	13.24
NW - 3	Ponderosa Pine, 1970	151.28	17.91
	1971	146.31	11.23
	1972	144.80	4.60
	1973	215.26	7.23
	Silver Sage	308.23	6.82
	Bluebunch Wheatgrass	142.29	7.30
NW - 4	Ponderosa Pine, 1970	177.99	9.73
	1971	173.68	21.11
	1972	160.59	6.99
	1973	211.52	6.14
	Little Bluestem	191.38	20.36
A - 1	Moss	218.45	8.26
A - 2	Moss	140.62	5.74
	Rush[11]	204.15	10.11
A - 3	Moss	152.87	7.80
A - 4	Moss	182.54	11.47
A - 5	Moss	96.33	6.41
A - 5	Moss	104.81	7.39
A - 6	Moss	171.08	9.17

TABLE 6 (cont.)

Site	Sample Description	Gross Beta (pCi/g-ash)	Gross Alpha (pCi/g-ash)
A - 7	Moss	143.02	5.93
A - 8	Moss	135.29	6.84
A - 9	Moss	104.09	6.16
A -10	Moss	121.06	7.33

1 Pinus Ponderosa
2 Artemesia Cana
3 Andropogan Scoparius
4 Artemesia Tridentata
5 Agropyron Spicatum
6 Juniperus Scopulorum
7 Calamovilfa Longifolia
8 Rhus Trilobata
9 Chrysothamnus Nauseosus
10 Symphoriocarpus
11 Scirpus

TABLE 7
Gross Beta Activity in Air Samples Collected At
The Burlington Northern Air Sampling Site

Month	Date	Beta Activity (pCi/m^3)	2 Sigma Counting Error	Monthly Average (pCi/m^3)
November, 1973	19	.08	.01	.08
	22	.12	.01	
	25	.07	.01	
	28	.05	.01	
December, 1973	1	.07	.01	.07
	4	.09	.01	
	7	.05	.01	
	10	.08	.01	
	13	.07	.01	
	16	.09	.01	
	19	.08	.01	
	22	.08	.01	
	25	.05	.01	
	28	.06	.01	
	31	.09	.01	
January, 1974	3	.06	.01	.11
	6	.05	.01	
	9	.09	.01	
	12	.15	.01	
	15	.17	.01	
	18	.10	.01	
	21	.10	.01	
	24	.05	.01	
	27	.14	.01	
	30	.15	.01	
February, 1974	2	.07	.01	.14
	5	.18	.01	
	8	.11	.01	
	11	.23	.02	
	14	.10	.01	
	17	.16	.01	
	20	.12	.01	
	23	.07	.01	
	26	.19	.02	
March, 1974	1	.20	.02	.19
	4	.08	.01	
	7	.14	.01	
	10	.23	.02	

TABLE 7 (cont.)

Month	Date	Beta Activity (pCi/m^3)	2 Sigma Counting Error	Monthly Average (pCi/m^3)
March, 1974	13	.30	.02	
	16	.18	.02	
	19	.10	.01	
	22	.12	.01	
	25	.30	.02	
	28	.34	.02	
	31	.10	.01	
April, 1974	3	.14	.01	.30
	6	.32	.02	
	9	.15	.01	
	12	.13	.01	
	15	.30	.02	
	18	.60	.03	
	21	.34	.02	
	24	.34	.02	
	27	.40	.02	
	30	.28	.02	
May, 1974	3	.15	.01	.31
	6	.29	.02	
	9	.39	.02	
	12	.28	.02	
	15	.38	.02	
	18	.14	.01	
	21	.45	.03	
	24	.18	.02	
	27	.26	.02	
	30	.58	.03	
June, 1974	2	.50	.03	.34
	5	.35	.02	
	8	.28	.02	
	11	.33	.02	
	14	.31	.02	
	17	.28	.02	
	20	.21	.02	
	23	.41	.03	
	26	.34	.02	
	29	.38	.02	

TABLE 8

Gross Beta Activity in Air Samples Collected at
The McRae Air Sampling Site

Month	Date	Beta Activity (pCi/m^3)	2 Sigma Counting Error	Monthly Average (pCi/m^3)
November, 1973	19	.07	.01	.08
	22	.12	.01	
	25	.07	.01	
	28	.06	.01	
December, 1973	1	.09	.01	.09
	4	.10	.01	
	7	.09	.01	
	10	.07	.01	
	13	.07	.01	
	16	.08	.01	
	19	.11	.01	
	25	.06	.01	
	28	.09	.01	
	31	.09	.01	
January, 1974	3	.06	.01	.10
	6	.06	.01	
	9	.10	.01	
	12	.15	.01	
	15	.12	.01	
	18	.10	.01	
	21	.12	.01	
	24	.07	.01	
	27	.07	.01	
	30	.17	.01	
February, 1974	2	.06	.01	.13
	5	.10	.01	
	8	.08	.01	
	11	.18	.02	
	14	.14	.01	
	17	.17	.02	
	20	.09	.01	
	23	.09	.01	
	26	.24	.02	
March, 1974	10	.27	.04	.22
	13	.30	.02	
	16	.11	.01	
	19	.16	.01	
	22	.16	.01	
	25	.31	.02	
	28	.25	.02	
	31	.22	.02	

TABLE 8 (cont.)

Month	Date	Beta Activity (pCi/m^3)	2 Sigma Counting Error	Monthly Average (pCi/m^3)
April, 1974	3	.13	.01	.32
	6	.17	.02	
	9	.39	.02	
	12	.10	.01	
	15	.48	.03	
	18	.54	.03	
	21	.40	.02	
	24	.47	.03	
	27	.31	.02	
	30	.20	.02	
May, 1974	3	.35	.02	.31
	6	.37	.02	
	9	.54	.02	
	12	.16	.01	
	15	.34	.02	
	18	.02	.01	
	21	.52	.02	
	24	.37	.02	
	27	.16	.02	
	30	.22	.02	
June, 1974	2	.60	.03	.37
	5	.45	.03	
	8	.26	.02	
	11	.38	.02	
	14	.31	.02	
	17	.29	.02	
	20	.22	.02	
	23	.09	.01	
	26	.68	.03	
	29	.43	.03	

APPENDIX F: COAL CONTENT ANALYSES

F1: Statistical Summaries of Coal Content Analyses

TABLE 1

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA C   SEAM RUSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 01/01/64 THRU 04/17/74

	(01) PROX ANAL %MOISTURE AS RCVD	(02) PROX ANAL % ASH AS RCVD	(03) PROX ANAL %VOLATILE AS RCVD	(04) PROX ANAL %FIX CARB AS RCVD	(05) PROX ANAL BTU/LB AS RCVD	(06) PROX ANAL %SULFUR AS RCVD	(07) PROX ANAL %MOISTURE AIR DRY	(08) PROX ANAL %MOISTURE ADRY LOSS	(17) ULT ANAL %MOISTURE AS RCVD	(18) ULT ANAL % CARBON AS RCVD
NUMBER OF VALUES	93	93	93	93	93	93	0	0	93	93
MINIMUM VALUE	20.61	4.14	27.02	29.95	7365	.40	.00	.00	20.61	41.87
MAXIMUM VALUE	30.75	18.36	35.26	38.42	9028	7.40	.00	.00	30.75	51.74
MEAN VALUE	25.65	10.16	29.70	34.47	8383.24	.89	.00	.00	25.65	48.71
MEDIAN	25.40	9.96	29.63	34.42	8423	.80	.00	.00	25.40	48.75
STANDARD DEVIATION	1.488	1.764	1.154	1.361	244.001	.727			1.488	1.538
COEFFICIENT OF VARIANCE	5.800	17.363	3.884	3.948	2.911	81.645			5.800	3.157
MINIMUM MID-MEAN SAMPLE	24.80	9.19	28.86	33.92	8266	.64	.00	.00	24.80	48.11
MAXIMUM MID-MEAN SAMPLE	26.54	10.81	30.32	35.08	8527	.94	.00	.00	26.54	49.79
MEAN MID-MEAN SAMPLE	25.55	10.00	29.68	34.43	2024.38	.79	.00	.00	25.55	48.80
VARIANCE	2.213	3.112	1.331	1.852	59536.552	.528	.000	.000	2.213	2.365

TABLE 2

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA C   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 01/01/64 THRU 04/17/74

	(11) PROX ANAL % ASH OVEN DRY	(12) PROX ANAL %VOLATILE OVEN DRY	(13) PROX ANAL %FIX CARB OVEN DRY	(14) PROX ANAL BTU/LB OVEN DRY	(15) PROX ANAL %SULFUR OVEN DRY	(66) MOL CAO / MOL S	(67) MOL MG O / MOL S	(68) MOL CA O + MG O/ MOL S	(09) LBS ASH / MILL BTU	(10) LBS SULF / MILL BTU
NUMBER OF VALUES	93	93	93	93	93	93	93	93	93	93
MINIMUM VALUE	5.71	35.87	39.76	9362.64	.53	.05	.02	.06	4.59	.47
MAXIMUM VALUE	24.37	40.29	52.96	12445.55	9.32	2.60	.79	3.29	24.93	9.96
MEAN VALUE	13.65	39.96	46.38	11279.32	1.19	.90	.39	1.28	12.17	1.08
MEDIAN	13.40	39.80	46.50	11310.47	1.07	.75	.37	1.12	11.86	.94
STANDARD DEVIATION	2.205	1.521	1.910	365.553	.914	.453	.158	.548	2.486	.982
COEFFICIENT OF VARIANCE	16.155	3.805	4.118	3.242	76.834	50.308	40.542	42.791	20.429	90.911
MINIMUM MID-MEAN SAMPLE	12.47	38.97	45.46	11153.44	.86	.63	.29	.93	10.91	.75
MAXIMUM MID-MEAN SAMPLE	14.53	40.92	47.30	11456.13	1.28	1.06	.48	1.50	13.04	1.14
MEAN MID-MEAN SAMPLE	13.46	39.90	46.43	661.14	1.06	.81	.37	1.18	11.91	.93
VARIANCE	4.863	2.312	3.647	33702.099	.836	.205	.025	.300	6.181	.964

TABLE 3

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA C SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 01/01/64 THRU 04/17/74

	(19) ULT ANAL %HYDROGEN AS RCVD	(20) ULT ANAL %NITROGEN AS RCVD	(21) ULT ANAL %CHLORINE AS RCVD	(22) ULT ANAL %SULFUR AS RCVD	(23) ULT ANAL % ASH AS RCVD	(24) ULT ANAL %OXYGEN AS RCVD	(25) ULT ANAL % CARBON DRY BASIS	(26) ULT ANAL %HYDROGEN DRY BASIS	(27) ULT ANAL %NITROGEN DRY BASIS	(28) ULT ANAL %CHLORINE DRY BASIS
NUMBER OF VALUES	93	93	93	93	93	93	93	93	93	93
MINIMUM VALUE	2.91	.47	.00	.40	4.14	8.34	52.74	3.83	.65	.00
MAXIMUM VALUE	3.64	1.40	.02	7.40	18.36	11.82	71.33	5.02	1.86	.03
MEAN VALUE	3.35	.73	.00	.89	10.16	10.48	65.53	4.51	.98	.01
MEDIAN	3.38	.71	.01	.80	9.96	10.44	65.85	4.55	.95	.01
STANDARD DEVIATION	.141	.130	.000	.727	1.764	.549	2.235	.202	.170	.000
COEFFICIENT OF VARIANCE	4.222	17.861		81.645	17.363	5.235	3.411	4.490	17.377	.000
MINIMUM MID-MEAN SAMPLE	3.28	.66	.00	.64	9.19	10.09	64.61	4.42	.89	.00
MAXIMUM MID-MEAN SAMPLE	3.45	.77	.01	.94	10.81	10.83	66.62	4.63	1.04	.02
MEAN MID-MEAN SAMPLE	3.37	.71	.01	.79	10.00	10.46	65.72	4.54	.96	.01
VARIANCE	.020	.017	.000	.528	3.112	.301	4.995	.041	.029	.000

TABLE 4

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

DATE 08/16/74

SELECTED AREA C SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 01/01/64 THRU 04/17/74

	(29) ULT ANAL %SULFUR DRY BASIS	(30) ULT ANAL % ASH DRY BASIS	(31) ULT ANAL %OXYGEN DRY BASIS	(38) FUSN TEMP REDUCING INIT DEFM	(39) FUSN TEMP OXIDIZING INIT DEFM	(40) FUSN TEMP REDUCING SOF H=W	(41) FUSN TEMP OXIDIZING SOF H=W	(42) FUSN TEMP REDUCING SOFH=1/2W	(43) FUSN TEMP OXIDIZING SOFH=1/2W	(44) FUSN TEMP FLUID REDUCING
NUMBER OF VALUES	93	93	93	93	93	93	93	93	93	93
MINIMUM VALUE	.54	5.71	10.50	1990	2220	2180	2240	2195	2275	2205
MAXIMUM VALUE	9.32	24.37	16.50	2390	2595	2420	2650	2460	2655	2580
MEAN VALUE	1.19	13.65	14.10	2236.23	2298.06	2275.05	2333.54	2305.64	2379.13	2379.83
MEDIAN	1.08	13.40	14.15	2240	2290	2270	2330	2300	2380	2360
STANDARD DEVIATION	.915	2.206	.787	48.906	48.221	41.091	49.174	45.668	57.701	80.957
COEFFICIENT OF VARIANCE	76.880	16.159	5.580	2.187	2.098	1.806	2.107	1.981	2.425	3.402
MINIMUM MID-MEAN SAMPLE	.35	12.47	13.65	2210	2270	2250	2300	2270	2340	2310
MAXIMUM MID-MEAN SAMPLE	1.28	14.53	14.61	2260	2310	2300	2350	2320	2410	2440
MEAN MID-MEAN SAMPLE	1.06	13.46	14.12	107.98	164.26	144.15	201.06	171.06	247.23	241.81
VARIANCE	.837	4.865	.619	2391.751	2325.287	1688.438	2418.055	2085.606	3329.368	6554.006

TABLE 5

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA C   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 01/01/64 THRU 04/17/74

	(45) FUSN TEMP FLUID OXIDIZING	(32) PYRITIC SULFUR AS RCVD	(33) SULFATE SULFUR AS RCVD	(34) ORGANIC SULFUR AS RCVD	(35) PYRITIC SULFUR DRY BASIS	(36) SULFATE SULFUR DRY BASIS	(37) ORGANIC SULFUR DRY BASIS	(46) ASH ANAL P2 O5 PERCENT	(47) ASH ANAL SI O2 PERCENT	(48) ASH ANAL FE2 O3 PERCENT
NUMBER OF VALUES	93	93	93	93	93	93	93	93	93	93
MINIMUM VALUE	2285	.13	.00	.05	.17	.00	.07	.05	16.46	3.18
MAXIMUM VALUE	2680	5.48	.24	1.88	6.90	.33	2.37	.86	53.97	51.96
MEAN VALUE	2457.20	.42	.01	.45	.56	.02	.61	.35	43.16	7.76
MEDIAN	2460	.32	.01	.43	.43	.01	.57	.35	43.79	6.46
STANDARD DEVIATION	75.848	.560	.032	.219	.708	.032	.281	.161	5.686	5.624
COEFFICIENT OF VARIANCE	3.087	133.418	316.228	48.636	126.395	158.114	46.077	46.070	13.174	72.469
MINIMUM MID-MEAN SAMPLE	2400	.24	.01	.36	.31	.01	.48	.24	40.64	5.04
MAXIMUM MID-MEAN SAMPLE	2500	.42	.02	.49	.57	.03	.65	.43	46.46	8.50
MEAN MID-MEAN SAMPLE	328.51	.32	.01	.42	.43	.01	.57	.33	43.75	6.62
VARIANCE	5752.937	.314	.001	.048	.501	.001	.079	.026	32.330	31.625

TABLE 6

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA C SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 01/01/64 THRU 04/17/74

	(49) ASH ANAL AL2 O3 PERCENT	(50) ASH ANAL TI O2 PERCENT	(51) ASH ANAL CA O PERCENT	(52) ASH ANAL MG O PERCENT	(53) ASH ANAL S O3 PERCENT	(54) ASH ANAL K2 O PERCENT	(55) ASH ANAL NA2 O PERCENT	(56) ASH ANAL UNDETER PERCENT	(16) HRDGROVE GRINDA-BILITY	(71) ALKALIES AS NA2 O DCB
NUMBER OF VALUES	93	93	93	93	93	93	93	93	93	93
MINIMUM VALUE	12.30	.25	3.50	.49	4.16	.16	.12	.02	39.30	.02
MAXIMUM VALUE	25.57	1.36	29.10	7.90	20.21	2.81	2.36	1.34	73.70	.52
MEAN VALUE	18.95	.72	11.78	3.78	11.74	.69	.42	.60	52.37	.12
MEDIAN	18.93	.72	11.10	3.78	11.73	.60	.31	.59	51.90	.10
STANDARD DEVIATION	2.119	.230	4.074	1.172	2.387	.394	.359	.281	4.224	.084
COEFFICIENT OF VARIANCE	11.182	31.975	34.581	31.010	20.333	57.058	85.516	46.845	8.065	69.722
MINIMUM MID-MEAN SAMPLE	17.69	.58	9.55	3.08	10.67	.41	.20	.45	49.50	.07
MAXIMUM MID-MEAN SAMPLE	20.22	.89	12.75	4.34	13.16	.81	.48	.77	55.00	.14
MEAN MID-MEAN SAMPLE	18.89	.72	10.99	3.76	11.75	.62	.33	.60	51.96	.10
VARIANCE	4.490	.053	16.595	1.374	5.698	.155	.129	.079	17.841	.007

TABLE 7

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA C   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 01/01/64 THRU 04/17/74

	(69) BASE-ACID RATIO	(70) IRON RATIO
NUMBER OF VALUES	93	93
MINIMUM VALUE	.26	.13
MAXIMUM VALUE	1.50	11.92
MEAN VALUE	.40	.62
MEDIAN	.36	.43
STANDARD DEVIATION	.170	1.210
COEFFICIENT OF VARIANCE	42.573	195.155
MINIMUM MID-MEAN SAMPLE	.31	.32
MAXIMUM MID-MEAN SAMPLE	.42	.63
MEAN MID-MEAN SAMPLE	.36	.44
VARIANCE	.029	1.464

TABLE 8

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA C   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 01/01/64 THRU 04/17/74

	(72) SILICA VALUE	(57) ASH ANAL CA O SO3 FREE	(58) ASH ANAL MG O SO3 FREE	(59) ASH ANAL NA2 O SO3 FREE	(60) ASH ANAL FE2 O3 SO3 FREE	(61) ASH ANAL K2 O SO3 FREE	(62) ASH ANAL AL2 O3 SO3 FREE	(63) ASH ANAL SI O2 SO3 FREE	(64) ASH ANAL P2 O5 SO3 FREE	(65) ASH ANAL TI O2 SO3 FREE
NUMBER OF VALUES	93	93	93	93	93	93	93	93	93	93
MINIMUM VALUE	28.84	3.66	.57	.14	3.62	.19	13.59	20.63	.06	.28
MAXIMUM VALUE	76.59	32.71	8.83	2.72	54.31	2.93	28.79	58.63	.99	1.63
MEAN VALUE	64.93	13.41	4.28	.43	8.77	.78	21.49	48.86	.39	.82
MEDIAN	66.75	12.55	4.34	.36	7.26	.68	21.40	50.15	.39	.83
STANDARD DEVIATION	8.115	4.764	1.322	.410	6.019	.428	2.467	6.009	.184	.263
COEFFICIENT OF VARIANCE	12.498	35.524	30.891	85.391	68.627	54.844	11.480	12.298	47.280	32.034
MINIMUM MID-MEAN SAMPLE	61.63	10.79	3.51	.24	5.76	.47	20.06	46.55	.27	.67
MAXIMUM MID-MEAN SAMPLE	69.32	14.53	5.01	.53	9.95	.95	22.35	52.36	.50	1.00
MEAN MID-MEAN SAMPLE	66.29	12.48	4.27	.37	7.52	.70	21.43	49.78	.37	.82
VARIANCE	65.352	22.693	1.748	.168	36.223	.183	6.086	36.103	.034	.069

TABLE 9

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA D   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(01) PROX ANAL %MOISTURE AS RCVD	(02) PROX ANAL % ASH AS RCVD	(03) PROX ANAL %VOLATILE AS RCVD	(04) PROX ANAL %FIX CARB AS RCVD	(05) PROX ANAL BTU/LB AS RCVD	(06) PROX ANAL %SULFUR AS RCVD	(07) PROX ANAL %MOISTURE AIR DRY	(08) PROX ANAL %MOISTURE ADRY LOSS	(17) ULT ANAL %MOISTURE AS RCVD	(18) ULT ANAL % CARBON AS RCVD
NUMBER OF VALUES	41	41	41	41	41	41	0	0	38	38
MINIMUM VALUE	23.50	7.10	28.30	33.82	8247	.30	.00	.00	23.50	47.86
MAXIMUM VALUE	28.63	10.15	31.48	38.36	8810	1.04	.00	.00	28.63	51.76
MEAN VALUE	25.90	8.31	29.89	35.89	8564.29	.73	.00	.00	25.86	49.97
MEDIAN	25.90	8.19	29.98	35.71	8579	.74	.00	.00	25.81	50.02
STANDARD DEVIATION	1.066	.749	.918	1.090	127.453	.148			1.092	.820
COEFFICIENT OF VARIANCE	4.115	9.013	3.072	3.038	1.483	20.318			4.224	1.642
MINIMUM MID-MEAN SAMPLE	24.96	7.64	29.00	35.13	8482	.65	.00	.00	24.94	49.47
MAXIMUM MID-MEAN SAMPLE	26.75	8.51	30.68	36.32	8640	.77	.00	.00	26.75	50.49
MEAN MID-MEAN SAMPLE	25.83	8.16	29.89	35.78	3803.95	.72	.00	.00	25.75	49.94
VARIANCE	1.136	.561	.843	1.189	16244.207	.022	.000	.000	1.193	.673

TABLE 10

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
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SELECTED AREA D   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(11) PROX ANAL % ASH OVEN DRY	(12) PROX ANAL %VOLATILE OVEN DRY	(13) PROX ANAL %FIX CARB OVEN DRY	(14) PROX ANAL BTU/LB OVEN DRY	(15) PROX ANAL %SULFUR OVEN DRY	(66) MOL CAO / MOL S	(67) MOL MG O / MOL S	(68) MOL CA O + MG O/ MOL S	(09) LBS ASH / MILL BTU	(10) LBS SULF / MILL BTU
NUMBER OF VALUES	41	41	41	41	41	38	38	38	41	41
MINIMUM VALUE	9.73	37.75	45.07	11053.48	.41	.60	.16	.86	8.30	.36
MAXIMUM VALUE	13.53	43.12	51.47	11905.48	1.39	5.53	.86	6.40	12.08	1.26
MEAN VALUE	11.21	40.34	48.44	11559.36	.98	1.18	.40	1.58	9.71	.85
MEDIAN	11.00	40.25	48.46	11514.51	1.00	.93	.39	1.37	9.47	.87
STANDARD DEVIATION	.923	1.166	1.434	191.070	.195	.802	.122	.879	.947	.173
COEFFICIENT OF VARIANCE	8.234	2.890	2.960	1.653	19.891	67.955	30.619	55.610	9.754	20.377
MINIMUM MID-MEAN SAMPLE	10.46	39.36	47.53	11435.50	.87	.81	.31	1.15	8.87	.75
MAXIMUM MID-MEAN SAMPLE	11.39	41.12	49.43	11717.58	1.04	1.18	.46	1.64	10.02	.90
MEAN MID-MEAN SAMPLE	11.01	40.32	48.43	2032.78	.98	.97	.39	1.38	9.50	.85
VARIANCE	.852	1.359	2.056	36507.883	.038	.643	.015	.772	.897	.030

TABLE 11

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA D SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 00/00/00 THRU 99/99/99

	(19) ULT ANAL %HYDROGEN AS RCVD	(20) ULT ANAL %NITROGEN AS RCVD	(21) ULT ANAL %CHLORINE AS RCVD	(22) ULT ANAL %SULFUR AS RCVD	(23) ULT ANAL % ASH AS RCVD	(24) ULT ANAL %OXYGEN AS RCVD	(25) ULT ANAL % CARBON DRY BASIS	(26) ULT ANAL %HYDROGEN DRY BASIS	(27) ULT ANAL %NITROGEN DRY BASIS	(28) ULT ANAL %CHLORINE DRY BASIS
NUMBER OF VALUES	38	38	38	38	38	38	38	38	38	38
MINIMUM VALUE	3.12	.56	.00	.30	7.10	9.86	64.15	4.23	.77	.00
MAXIMUM VALUE	3.52	.89	.02	1.04	10.15	11.88	69.38	4.86	1.18	.03
MEAN VALUE	3.37	.71	.00	.73	8.33	10.98	67.40	4.55	.96	.01
MEDIAN	3.39	.73	.01	.75	8.33	10.99	67.49	4.59	.97	.01
STANDARD DEVIATION	.100	.071	.000	.152	.771	.428	.982	.145	.089	.000
COEFFICIENT OF VARIANCE	2.967	9.959		20.775	9.252	3.896	1.457	3.185	9.317	.000
MINIMUM MID-MEAN SAMPLE	3.33	.67	.00	.65	7.61	10.73	66.88	4.45	.91	.00
MAXIMUM MID-MEAN SAMPLE	3.43	.75	.01	.77	8.52	11.24	67.95	4.65	1.02	.02
MEAN MID-MEAN SAMPLE	3.39	.72	.01	.72	8.18	10.96	67.52	4.57	.97	.01
VARIANCE	.010	.005	.000	.023	.594	.183	.965	.021	.008	.000

TABLE 12

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA D SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 00/00/00 THRU 99/99/99

	(29) ULT ANAL %SULFUR DRY BASIS	(30) ULT ANAL % ASH DRY BASIS	(31) ULT ANAL %OXYGEN DRY BASIS	(38) FUSN TEMP REDUCING INIT DEFM	(39) FUSN TEMP OXIDIZING INIT DEFM	(40) FUSN TEMP REDUCING SOF H=W	(41) FUSN TEMP OXIDIZING SOF H=W	(42) FUSN TEMP REDUCING SOFH=1/2W	(43) FUSN TEMP OXIDIZING SOFH=1/2W	(44) FUSN TEMP FLUID REDUCING
NUMBER OF VALUES	38	38	38	38	38	38	38	38	38	38
MINIMUM VALUE	.41	9.73	13.49	2140	2200	2180	2250	2200	2260	2210
MAXIMUM VALUE	1.40	13.52	15.17	2360	2370	2370	2380	2400	2405	2460
MEAN VALUE	.98	11.24	14.62	2237.50	2284.47	2254.00	2301.05	2270.00	2321.31	2298.42
MEDIAN	1.01	11.19	14.80	2230	2280	2250	2300	2260	2320	2300
STANDARD DEVIATION	.200	.951	.563	41.067	26.823	39.107	25.344	38.406	29.551	45.597
COEFFICIENT OF VARIANCE	20.408	8.459	3.335	1.835	1.174	1.735	1.101	1.692	1.273	1.984
MINIMUM MID-MEAN SAMPLE	.86	10.40	14.40	2210	2270	2230	2280	2240	2300	2260
MAXIMUM MID-MEAN SAMPLE	1.04	11.53	15.13	2260	2295	2280	2310	2290	2330	2320
MEAN MID-MEAN SAMPLE	.98	11.03	14.77	2236.00	2281.50	2248.60	2296.50	2262.00	2315.25	2292.00
VARIANCE	.040	.904	.323	1686.513	719.460	1529.368	642.314	1475.000	873.269	2079.085

TABLE 13

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

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SELECTED AREA D SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 00/00/00 THRU 99/99/99

	(45) FUSN TEMP FLUID OXIDIZING	(32) PYRITIC SULFUR AS RCVD	(33) SULFATE SULFUR AS RCVD	(34) ORGANIC SULFUR AS RCVD	(35) PYRITIC SULFUR DRY BASIS	(36) SULFATE SULFUR DRY BASIS	(37) ORGANIC SULFUR DRY BASIS	(46) ASH ANAL P2 05 PERCENT	(47) ASH ANAL SI 02 PERCENT	(48) ASH ANAL FE2 03 PERCENT
NUMBER OF VALUES	38	38	38	38	38	38	38	38	38	38
MINIMUM VALUE	2270	.12	.00	.11	.16	.00	.15	.12	24.64	2.96
MAXIMUM VALUE	2640	.64	.04	.74	.86	.05	.99	.66	44.51	10.26
MEAN VALUE	2368.28	.29	.01	.42	.39	.02	.56	.35	38.08	6.43
MEDIAN	2350	.27	.01	.41	.37	.02	.56	.34	38.66	6.29
STANDARD DEVIATION	66.839	.126	.000	.118	.170	.000	.155	.138	4.498	1.825
COEFFICIENT OF VARIANCE	2.822	43.618	.000	28.172	43.665	.000	27.664	39.383	11.812	28.388
MINIMUM MID-MEAN SAMPLE	2320	.20	.01	.35	.27	.01	.48	.26	34.82	5.03
MAXIMUM MID-MEAN SAMPLE	2390	.34	.02	.46	.45	.03	.51	.40	41.67	7.81
MEAN MID-MEAN SAMPLE	2349.50	.26	.01	.41	.35	.02	.55	.33	38.39	6.20
VARIANCE	4467.469	.016	.000	.014	.029	.000	.024	.019	20.232	3.332

TABLE 14

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MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA D   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(49) ASH ANAL AL2 O3 PERCENT	(50) ASH ANAL TI O2 PERCENT	(51) ASH ANAL CA O PERCENT	(52) ASH ANAL MG O PERCENT	(53) ASH ANAL S O3 PERCENT	(54) ASH ANAL K2 O PERCENT	(55) ASH ANAL NA2 O PERCENT	(56) ASH ANAL UNDETER PERCENT	(16) HRDGROVE GRINDA-BILITY	(71) ALKALIES AS NA2 O DCB
NUMBER OF VALUES	38	38	38	38	38	38	38	38	38	38
MINIMUM VALUE	13.08	.40	12.16	2.28	12.15	.20	.18	.28	50.80	.01
MAXIMUM VALUE	20.90	1.03	31.63	5.73	18.27	1.48	3.14	1.67	66.50	1.10
MEAN VALUE	16.75	.72	16.57	4.27	15.07	.38	.54	.79	56.76	.12
MEDIAN	16.08	.72	14.65	4.37	15.02	.30	.34	.72	56.50	.07
STANDARD DEVIATION	2.059	.170	4.981	.804	1.338	.263	.543	.387	3.683	.187
COEFFICIENT OF VARIANCE	12.290	23.652	30.061	18.823	8.880	69.126	100.581	49.025	6.489	155.902
MINIMUM MID-MEAN SAMPLE	15.43	.58	13.21	3.55	13.98	.22	.27	.51	53.50	.05
MAXIMUM MID-MEAN SAMPLE	17.72	.84	16.85	4.84	15.91	.41	.54	.84	58.70	.10
MEAN MID-MEAN SAMPLE	16.31	.72	14.89	4.31	14.99	.31	.35	.69	55.93	.07
VARIANCE	4.238	.029	24.812	.646	1.791	.069	.295	.150	13.567	.035

TABLE 15

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

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SELECTED AREA D   SEAM ROSEBUD (59)   SOURCE ALL (70)   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	BASE-ACID RATIO	IRON RATIO
NUMBER OF VALUES	38	38
MINIMUM VALUE	.37	.10
MAXIMUM VALUE	1.08	.57
MEAN VALUE	.52	.32
MEDIAN	.48	.30
STANDARD DEVIATION	.152	.114
COEFFICIENT OF VARIANCE	29.165	35.630
MINIMUM MID-MEAN SAMPLE	.42	.26
MAXIMUM MID-MEAN SAMPLE	.54	.37
MEAN MID-MEAN SAMPLE	.47	.31
VARIANCE	.023	.013

TABLE 16

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA D SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 00/00/00 THRU 99/99/99

	(72) SILICA VALUE	(57) ASH ANAL CA O SO3 FREE	(58) ASH ANAL MG O SO3 FREE	(59) ASH ANAL NA2 O SO3 FREE	(60) ASH ANAL FE2 O3 SO3 FREE	(61) ASH ANAL K2 O SO3 FREE	(62) ASH ANAL AL2 O3 SO3 FREE	(63) ASH ANAL SI O2 SO3 FREE	(64) ASH ANAL P2 O5 SO3 FREE	(65) ASH ANAL TI O2 SO3 FREE
NUMBER OF VALUES	38	38	38	38	33	38	33	38	38	38
MINIMUM VALUE	36.97	14.45	2.75	.20	3.44	.23	15.48	29.86	.14	.48
MAXIMUM VALUE	66.24	36.00	6.68	3.74	12.38	1.76	24.68	51.62	.77	1.19
MEAN VALUE	58.28	19.52	5.03	.63	7.59	.45	19.73	44.82	.41	.85
MEDIAN	59.00	17.76	5.21	.41	7.49	.35	19.16	45.51	.40	.86
STANDARD DEVIATION	6.741	5.825	.933	.642	2.209	.311	2.409	5.116	.161	.197
COEFFICIENT OF VARIANCE	11.566	29.839	18.650	101.384	29.108	69.211	12.207	11.414	39.328	23.233
MINIMUM MID-MEAN SAMPLE	54.73	15.61	4.16	.32	5.89	.27	17.97	42.36	.31	.69
MAXIMUM MID-MEAN SAMPLE	63.15	19.86	5.63	.63	9.27	.48	20.99	48.68	.47	.99
MEAN MID-MEAN SAMPLE	59.38	17.57	5.08	.41	7.33	.36	19.25	45.28	.39	.84
VARIANCE	45.440	33.925	.880	.412	4.881	.097	5.801	26.172	.026	.039

TABLE 17

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA F SEAM ROSEBUD SOURCE ALL HOLE ALL TIME RANGE 00/00/00 THRU 99/99/99

	(01) PROX ANAL %MOISTURE AS RCVD	(02) PROX ANAL % ASH AS RCVD	(03) PROX ANAL %VOLATILE AS RCVD	(04) PROX ANAL %FIX CARB AS RCVD	(05) PROX ANAL BTU/LB AS RCVD	(06) PROX ANAL %SULFUR AS RCVD	(07) PROX ANAL %MOISTURE AIR DRY	(08) PROX ANAL %MOISTURE ADRY LOSS	(17) ULT ANAL %MOISTURE AS RCVD	(18) ULT ANAL % CARBON AS RCVD
NUMBER OF VALUES	31	31	31	31	31	31	0	31	33	33
MINIMUM VALUE	19.70	6.90	26.70	36.90	8245	.45	.00	10.90	19.70	48.56
MAXIMUM VALUE	26.50	10.10	31.60	41.30	9182	1.37	.00	21.70	26.50	57.25
MEAN VALUE	24.64	8.19	28.60	38.43	8554.58	.78	.00	17.01	24.63	50.46
MEDIAN	24.90	8.10	28.40	38.40	8528	.73	.00	17.20	24.80	49.74
STANDARD DEVIATION	1.532	.819	1.049	.974	206.004	.217		2.834	1.487	1.754
COEFFICIENT OF VARIANCE	6.219	9.994	3.667	2.530	2.408	27.794		16.660	6.037	3.475
MINIMUM MID-MEAN SAMPLE	24.20	7.50	27.80	37.60	8341	.58	.00	13.80	24.20	49.21
MAXIMUM MID-MEAN SAMPLE	25.50	8.50	28.90	38.90	8565	.88	.00	18.70	25.50	50.82
MEAN MID-MEAN SAMPLE	24.84	8.01	28.33	38.31	2271.19	.72	.00	17.16	24.85	49.96
VARIANCE	2.348	.670	1.100	.948	42437.727	.047	.000	8.031	2.211	3.075

TABLE 18

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

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SELECTED AREA E   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(11) PROX ANAL % ASH OVEN DRY	(12) PROX ANAL %VOLATILE OVEN DRY	(13) PROX ANAL %FIX CARB OVEN DRY	(14) PROX ANAL BTU/LB OVEN DRY	(15) PROX ANAL %SULFUR OVEN DRY	(66) MOL CAO / MOL S	(67) MOL MG O / MOL S	(68) MOL CA O + MG O/ MOL S	(09) LBS ASH / MILL BTU	(10) LBS SULF / MILL BTU
NUMBER OF VALUES	31	31	31	31	31	0	0	0	31	31
MINIMUM VALUE	9.25	35.84	48.12	10964.10	.59	.00	.00	.00	7.99	.52
MAXIMUM VALUE	13.43	39.65	52.90	11820.51	1.34	.00	.00	.00	12.25	1.64
MEAN VALUE	10.36	37.95	51.07	11353.12	1.03	.00	.00	.00	9.59	.91
MEDIAN	10.75	38.04	51.09	11320.46	.96	.00	.00	.00	9.44	.84
STANDARD DEVIATION	1.070	.895	1.047	222.353	.288				1.092	.259
COEFFICIENT OF VARIANCE	9.349	2.358	2.050	1.963	27.971				11.385	28.444
MINIMUM MID-MEAN SAMPLE	9.84	37.17	50.20	11174.40	.78	.00	.00	.00	8.62	.67
MAXIMUM MID-MEAN SAMPLE	11.26	38.46	51.54	11458.50	1.17	.00	.00	.00	9.95	1.04
MEAN MID-MEAN SAMPLE	10.61	37.89	50.98	5062.00	.96	.00	.00	.00	9.30	.84
VARIANCE	1.144	.801	1.096	49663.267	.083	.000	.000	.000	1.192	.067

TABLE 19

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA E   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(19) ULT ANAL %HYDROGEN AS RCVD	(20) ULT ANAL %NITROGEN AS RCVD	(21) ULT ANAL %CHLORINE AS RCVD	(22) ULT ANAL %SULFUR AS RCVD	(23) ULT ANAL % ASH AS RCVD	(24) ULT ANAL %OXYGEN AS RCVD	(25) ULT ANAL % CARBON DRY BASIS	(26) ULT ANAL %HYDROGEN DRY BASIS	(27) ULT ANAL %NITROGEN DRY BASIS	(28) ULT ANAL %CHLORINE DRY BASIS
NUMBER OF VALUES	0	33	0	33	33	0	33	0	33	
MINIMUM VALUE	.00	.56	.00	.45	.89	.00	64.57	.00	.74	
MAXIMUM VALUE	.00	.82	.00	1.37	10.10	.00	70.15	.00	1.11	
MEAN VALUE	.00	.71	.00	.76	7.91	.00	66.72	.00	.94	
MEDIAN	.00	.70	.00	.72	7.90	.00	66.57	.00	.94	
STANDARD DEVIATION		.063		.214	1.480		1.173		.084	
COEFFICIENT OF VARIANCE		8.908		28.221	18.705		1.765		8.901	
MINIMUM MID-MEAN SAMPLE	.00	.67	.00	.53	7.40	.00	65.88	.00	.90	
MAXIMUM MID-MEAN SAMPLE	.00	.74	.00	.83	8.50	.00	67.21	.00	.97	
MEAN MID-MEAN SAMPLE	.00	.70	.00	.71	7.94	.00	66.55	.00	.94	
VARIANCE	.000	.004	.000	.046	2.180	.000	1.387	.000	.007	

TABLE 20

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA E   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(29) ULT ANAL %SULFUR DRY BASIS	(30) ULT ANAL % ASH DRY BASIS	(31) ULT ANAL %OXYGEN DRY BASIS	(38) FUSN TEMP REDUCING INIT DEFM	(39) FUSN TEMP OXIDIZING INIT DEFM	(40) FUSN TEMP REDUCING SOF H=W	(41) FUSN TEMP OXIDIZING SOF H=W	(42) FUSN TEMP REDUCING SOFH=1/2W	(43) FUSN TEMP OXIDIZING SOFH=1/2W	(44) FUSN TEMP FLUID REDUCING
NUMBER OF VALUES	33	33	0	33	33	33	33	33	33	33
MINIMUM VALUE	.59	9.40	.00	2160	2200	2170	2250	2180	2280	2190
MAXIMUM VALUE	1.35	13.50	.00	2330	2420	2350	2480	2370	2510	2450
MEAN VALUE	1.02	10.82	.00	2258.18	2307.27	2285.15	2338.18	2306.96	2369.69	2343.03
MEDIAN	.96	10.80	.00	2260	2310	2290	2340	2310	2370	2360
STANDARD DEVIATION	.288	1.053		40.261	43.573	41.569	42.743	45.024	47.831	54.075
COEFFICIENT OF VARIANCE	28.245	9.728		1.783	1.889	1.819	1.828	1.952	2.018	2.308
MINIMUM MID-MEAN SAMPLE	.77	9.90	.00	2230	2280	2250	2310	2270	2340	2300
MAXIMUM MID-MEAN SAMPLE	1.18	11.20	.00	2290	2330	2320	2360	2330	2390	2380
MEAN MID-MEAN SAMPLE	.95	10.59	.00	2256.47	2310.00	2283.53	2333.32	2302.94	2368.24	2345.88
VARIANCE	.083	1.108	.000	1620.936	1898.523	1728.008	1826.997	2027.181	2287.787	2924.151

TABLE 21

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
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SELECTED AREA 1   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(45) FUSN TEMP FLUID OXIDIZING	(32) PYRITIC SULFUR AS RCVD	(33) SULFATE SULFUR AS RCVD	(34) ORGANIC SULFUR AS RCVD	(35) PYRITIC SULFUR DRY BASIS	(36) SULFATE SULFUR DRY BASIS	(37) ORGANIC SULFUR DRY BASIS	(46) ASH ANAL P2 O5 PERCENT	(47) ASH ANAL SI O2 PERCENT	(48) ASH ANAL FE2 O3 PERCENT
NUMBER OF VALUES	33	0	0	0	0	0	0	33	33	33
MINIMUM VALUE	2300	.00	.00	.00	.00	.00	.00	.11	25.32	3.39
MAXIMUM VALUE	2540	.00	.00	.00	.00	.00	.00	.75	44.54	20.67
MEAN VALUE	2416.06	.00	.00	.00	.00	.00	.00	.34	37.25	7.99
MEDIAN	2410	.00	.00	.00	.00	.00	.00	.32	36.32	6.97
STANDARD DEVIATION	61.148							.134	4.472	3.775
COEFFICIENT OF VARIANCE	2.531							39.460	12.005	47.246
MINIMUM MID-MEAN SAMPLE	2380	.00	.00	.00	.00	.00	.00	.25	34.35	4.91
MAXIMUM MID-MEAN SAMPLE	2440	.00	.00	.00	.00	.00	.00	.39	39.52	10.17
MEAN MID-MEAN SAMPLE	2409.41	.00	.00	.00	.00	.00	.00	.32	37.09	7.18
VARIANCE	3739.027	.000	.000	.000	.000	.000	.000	.018	19.996	14.250

TABLE 22

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA F   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(49) ASH ANAL AL2 O3 PERCENT	(50) ASH ANAL TI O2 PERCENT	(51) ASH ANAL CA O PERCENT	(52) ASH ANAL MG O PERCENT	(53) ASH ANAL S O3 PERCENT	(54) ASH ANAL K2 O PERCENT	(55) ASH ANAL NA2 O PERCENT	(56) ASH ANAL UNDETER PERCENT	(16) HARDGROVE GRINDA-BILITY	(71) ALKALIES AS NA2 O DC3
NUMBER OF VALUES	33	33	33	33	33	33	33	33	29	33
MINIMUM VALUE	13.23	.14	9.78	3.24	12.71	.17	.11	.12	44.70	.03
MAXIMUM VALUE	20.54	1.38	29.25	5.77	20.32	.86	1.03	.92	59.40	8.85
MEAN VALUE	17.81	.68	14.37	4.31	16.02	.32	.37	.49	52.69	.33
MEDIAN	17.69	.66	13.39	4.23	15.41	.28	.31	.52	52.10	.06
STANDARD DEVIATION	1.645	.184	4.112	.612	1.971	.155	.197	.212	3.309	1.506
COEFFICIENT OF VARIANCE	9.236	27.116	28.614	14.208	12.305	48.412	53.374	43.292	7.228	456.360
MINIMUM MID-MEAN SAMPLE	16.72	.61	11.58	3.35	14.46	.22	.20	.33	50.50	.05
MAXIMUM MID-MEAN SAMPLE	18.85	.76	14.13	4.67	17.24	.33	.47	.64	54.60	.08
MEAN MID-MEAN SAMPLE	17.75	.68	13.23	4.21	15.63	.27	.32	.49	52.29	.06
VARIANCE	2.706	.034	16.907	.375	3.886	.024	.039	.045	14.505	2.268

TABLE 23

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

SELECTED AREA F   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(69) BASE-ACID RATIO	(70) IRON RATIO
NUMBER OF VALUES	33	33
MINIMUM VALUE	.30	.11
MAXIMUM VALUE	1.02	1.14
MEAN VALUE	.50	.45
MEDIAN	.46	.38
STANDARD DEVIATION	.158	.241
COEFFICIENT OF VARIANCE	31.523	53.518
MINIMUM MID-MEAN SAMPLE	.41	.28
MAXIMUM MID-MEAN SAMPLE	.56	.56
MEAN MID-MEAN SAMPLE	.47	.40
VARIANCE	.025	.058

TABLE 24

MONTANA POWER COMPANY
COAL SAMPLE ANALYSIS - STATISTICAL SUMMARY REPORT

PAGE 1
DATE 08/16/74

SELECTED AREA F   SEAM ROSEBUD   SOURCE ALL   HOLE ALL   TIME RANGE 00/00/00 THRU 99/99/99

	(72) SILICA VALUE	(57) ASH ANAL CA O SO3 FREE	(58) ASH ANAL MG O SO3 FREE	(59) ASH ANAL NA2 O SO3 FREE	(60) ASH ANAL FE2 O3 SO3 FREE	(61) ASH ANAL K2 O SO3 FREE	(62) ASH ANAL AL2 O3 SO3 FREE	(63) ASH ANAL SI O2 SO3 FREE	(64) ASH ANAL P2 O5 SO3 FREE	(65) ASH ANAL TI O2 SO3 FREE
NUMBER OF VALUES	33	33	33	33	33	33	33	33	33	33
MINIMUM VALUE	38.96	11.35	3.83	.13	4.18	.20	16.46	30.89	.13	.17
MAXIMUM VALUE	70.61	34.00	6.81	1.25	25.08	.99	24.26	52.15	.95	1.71
MEAN VALUE	58.31	17.12	5.14	.44	9.56	.38	21.21	44.30	.41	.81
MEDIAN	59.10	15.85	4.98	.37	8.44	.33	21.09	44.64	.38	.80
STANDARD DEVIATION	7.018	4.880	.750	.237	4.614	.182	1.896	4.729	.164	.228
COEFFICIENT OF VARIANCE	12.035	28.504	14.585	53.783	48.263	47.805	8.939	10.676	40.077	28.152
MINIMUM MID-MEAN SAMPLE	54.25	14.20	4.53	.24	5.74	.26	20.15	41.09	.31	.71
MAXIMUM MID-MEAN SAMPLE	62.50	17.20	5.43	.56	11.89	.39	22.46	46.41	.46	.91
MEAN MID-MEAN SAMPLE	58.56	15.93	5.03	.38	8.47	.33	21.24	44.31	.39	.80
VARIANCE	49.247	23.314	.562	.056	21.293	.033	3.595	22.367	.027	.052

F2 <u>Chemical Analyses of Coal from Four Core Holes in Rosebud County, Montana</u>

by: U.S. Geological Survey
Denver, Colorado 80225
September 17, 1974

Coordinators of study:

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Table 1.--Proximate, ultimate, Btu, and forms of sulfur analyses of eight composite core bench samples of coal from four core holes in Rosebud County, Mont. [Each sample represents the entire thickness of the bed. All analyses, except Btu, in percent; original moisture content may be slightly more than shown because samples were collected and transported in plastic bags to avoid metal contamination; form of analysis A, as received; B, air dried, C, moisture free; D, moisture and ash free. All analyses by Coal Analysis Section, U.S. Bureau of Mines, Pittsburgh, Pa.]

Sample No.	Form of analysis	PROXIMATE ANALYSIS Moisture	Volatile matter	Fixed carbon	Ash	ULTIMATE ANALYSIS Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Btu value	FORMS OF SULFUR Sulfate	Pyritic	Organic
ROSEBUD BED, 23 FEET THICK, (N46E64), SE 1/4 sec. 2, T. 1 N., R. 41 E.														
D168913	A	24.9	27.8	36.8	10.5	6.1	49.0	0.7	31.9	1.8	8,430	0.01	1.56	0.25
(USBM No.	B	15.3	31.4	41.5	11.8	5.5	55.2	.8	24.6	2.1	9,511	--	--	--
K-45641)	C	--	37.0	49.0	14.0	4.5	65.2	.9	13.0	2.4	11,230	.01	2.08	.33
	D	--	43.0	57.0	--	5.2	75.7	1.1	15.2	2.8	13,050	.01	2.41	.38
MCKAY BED, 8.2 FEET THICK, (N46E64), SE 1/4 sec. 2, T. 1 N., R. 41 E.														
D168914	A	27.0	26.3	40.2	6.5	6.2	50.7	0.7	34.8	1.1	8,690	0.01	0.88	0.24
(USBM No.	B	15.7	30.5	46.3	7.5	5.5	58.6	.9	26.2	1.3	10,040	--	--	--
K-45642)	C	--	36.1	55.0	8.9	4.4	69.5	1.0	14.6	1.6	11,910	.01	1.21	.33
	D	--	39.6	60.4	--	4.9	76.2	1.1	16.1	1.7	13,070	.01	1.33	.36
ROSEBUD BED, 22 FEET THICK, (N62E62.5), SE 1/4 sec. 23, T. 2 N., R. 41 E.														
D168916	A	25.7	28.0	37.6	8.7	6.2	49.6	0.8	33.7	1.0	8,550	0.01	0.73	0.31
(USBM No.	B	15.7	31.8	42.6	9.9	5.5	56.2	.9	26.3	1.2	9,690	--	--	--
K-45644)	C	--	37.7	50.5	11.8	4.5	66.7	1.0	14.6	1.4	11,500	.01	.98	.42
	D	--	42.7	57.3	--	5.1	75.6	1.2	16.5	1.6	13,030	.01	1.12	.47
MCKAY BED, 8.6 FEET THICK, (N62E62.5), SE 1/4 sec. 23, T. 2 N., R. 41 E.														
D168915	A	25.5	26.5	38.2	9.8	5.9	46.8	0.7	32.6	4.2	8,250	0.03	4.05	0.15
(USBM No.	B	15.8	30.0	43.1	11.1	5.3	52.9	.8	25.1	4.8	9,320	--	--	--
K-45643)	C	--	35.6	51.2	13.2	4.2	62.7	1.0	13.2	5.7	11,060	.04	5.44	.20
	D	--	41.0	59.0	--	4.8	72.3	1.1	15.3	6.5	12,750	.04	6.26	.23
ROSEBUD BED, 25 FEET THICK, (N47.5E34), NW 1/4 sec. 1, T. 1 N., R. 40 E.														
D168917	A	26.4	28.9	35.6	9.1	6.4	49.0	0.7	34.3	0.5	8,440	0.01	0.15	0.32
(USBM No.	B	15.7	33.0	40.9	10.4	5.7	56.1	.9	26.3	.6	9,660	--	--	--
K-45645)	C	--	39.2	48.5	12.3	4.6	66.5	1.0	14.9	.7	11,470	.01	.20	.44
	D	--	44.7	55.3	--	5.3	75.8	1.2	17.0	.7	13,070	.01	.23	.50
MCKAY BED, 6.4 FEET THICK, (N47.5E34), NW 1/4 sec. 1, T. 1 N., R. 40 E.														
D168918	A	27.0	28.3	37.8	6.9	6.3	50.2	0.8	34.9	0.9	8,600	0.01	0.63	0.29
(USBM No.	B	16.0	32.5	43.6	7.9	5.6	57.8	.9	26.7	1.1	9,680	--	--	--
K-45646)	C	--	38.8	51.7	9.5	4.5	68.8	1.0	14.9	1.3	11,790	.01	.87	.39
	D	--	42.8	57.2	--	5.0	76.0	1.1	16.5	1.4	13,020	.01	.96	.43
ROSEBUD BED, 23 FEET THICK, (N37E26.5), NE 1/4 sec. 15, T. 1 N., R. 40 E.														
D168920	A	24.1	27.1	33.3	15.5	5.8	44.4	0.7	29.5	4.1	7,810	0.01	3.98	0.13
(USBM No.	B	13.0	31.4	41.5	11.8	5.5	55.2	.8	24.6	2.1	9,510	--	--	--
K-45648)	C	--	35.7	43.9	20.4	4.0	58.5	.9	10.8	5.4	10,290	.01	5.24	.17
	D	--	44.8	55.2	--	5.1	73.4	1.1	13.6	6.8	12,920	.01	6.58	.22
MCKAY BED, 6.0 FEET THICK, (N37E26.5), NE 1/4 sec. 15, T. 1 N., R. 40 E.														
D168919	A	25.5	27.1	37.5	9.9	6.0	48.3	0.7	32.0	3.1	8,380	0.01	2.64	0.42
(USBM No.	B	13.9	31.4	43.2	11.5	5.2	55.8	.8	23.1	3.6	9,680	--	--	--
K-45647)	C	--	36.4	50.4	13.2	4.3	64.8	.9	12.7	4.1	11,240	.01	3.54	.57
	D	--	42.0	58.0	--	4.9	74.7	1.1	14.5	4.8	12,970	.01	4.09	.66

Table 2.--Major and minor element oxide composition, in percent, of the laboratory ash of 30 coal samples from four core holes in Rosebud County, Mont. [Chlorine analyses are in element percent. The coals were ashed at 525°C.]

Sample No.	Field No.	Thickness of sample interval (ft)	Ash	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2	MnO	P_2O_5	SO_3	Cl
ROSEBUD BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.															
D168872	N46E64-1R	6.	24.7	43.	17.	3.3	2.00	0.13	0.74	21.	0.41	0.036	< 0.10	8.4	< 0.10
D168873	N46E64-2R	5.	9.30	31.	16.	17.	4.40	.37	.027	4.8	.34	.14	< .10	17.	< .10
D168874	N46E64-3R	5.	9.05	39.	17.	13.	4.50	.41	.031	3.8	.62	.11	< .10	17.	< .10
D168875	N46E64-4R	5.	8.95	37.	20.	10.	3.98	.62	.081	1.2	.53	.093	< .10	11.	< .10
D168876	N46E64-5R	2.	20.9	29.	15.	16.	1.73	.26	.45	14.	.42	.15	< .10	9.4	< .10
MCKAY BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.															
D168877	N46E64-6M	4.	9.80	24.	14.	11.	3.10	0.44	0.024	16.	0.12	0.053	< 0.10	22.	< 0.10
D168878	N46E64-7M	4.2	8.31	16.	11.	10.	2.58	.90	.093	29.	.082	.038	< .10	22.	< .10
ROSEBUD BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R. 41 E.															
D168879	N62E62.5-1R	5.	13.3	47.	12.	8.3	2.98	0.16	< 0.020	8.2	0.62	0.060	< 0.10	16.	< 0.10
D168880	N62E62.5-2R	5.	11.9	50.	16.	8.6	3.28	.21	.94	3.1	.62	.098	< .10	13.	< .10
D168881	N62E62.5-3R	6.	10.4	40.	15.	12.	4.18	.20	< .020	4.4	.73	.090	< .10	18.	< .10
D168882	N62E62.5-4R	6.	11.0	32.	16.	10.	3.75	.24	.090	9.1	.65	.073	< .10	18.	< .10
MCKAY BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R. 41 E.															
D168883	N62E62.5-5M	4.3	8.97	23.	16.	11.	2.70	2.07	0.041	16.	0.33	0.023	< 0.10	23.	< 0.10
D168884	N62E62.5-6M	4.3	11.4	14.	7.9	7.3	1.95	1.78	.079	39.	.20	.034	< .10	20.	< .10
ROSEBUD BED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.															
D168885	N47.5E34-1R	5.	16.9	44.	17.	11.	2.50	0.12	1.8	4.3	0.52	0.069	< 0.10	9.6	< 0.10
D168886	N47.5E34-2R	5.	9.00	34.	17.	15.	4.35	.15	< .020	2.5	.56	.11	< .10	19.	< .10
D168887	N47.5E34-3R	5.	12.4	33.	10.	10.	3.00	.10	< .020	15.	.78	.067	< .10	21.	< .10
D168888	N47.5E34-4R	5.	18.6	11.	6.5	49.	2.15	.07	< .020	.39	.15	.031	< .10	6.3	< .10
D168889	N47.5E34-5R	5.	12.0	39.	24.	10.	3.03	.12	.17	1.2	.68	.19	< .10	13.	< .10
MCKAY BED (N47.5E34) NW 1/4 sec. 2, T. 1 N., R. 40 E.															
D168890	N47.5E34-6M	3.2	7.85	16.	12.	13.	2.90	0.90	0.13	16.	0.24	0.052	< 0.10	30.	< 0.10
D168891	N47.5E34-7M	3.2	9.77	24.	13.	12.	2.50	.62	.074	16.	.41	.076	< 0.10	26.	< .10
ROSEBUD BED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.															
D168892	N37E26.5-1R	5.	12.6	41.	15.	7.6	3.75	0.12	< 0.020	8.5	0.64	0.088	< 0.10	18.	< 0.10
D168893	N37E26.5-2R	5.	20.9	53.	16.	6.3	2.55	.12	2.0	5.1	.56	.072	< .10	8.9	< .10
D168894	N37E26.5-3R	5.	7.83	36.	17.	15.	5.90	.21	.083	3.0	.91	.10	< .10	19.	< .10
D168895	N37E26.5-4R	5.	8.39	31.	18.	14.	4.93	.20	.12	3.6	.49	.12	< .10	20.	< .10
D168896	N37E26.5-5R	3.	15.0	40.	16.	6.4	2.53	.12	.07	13.	.65	.051	< .10	14.	< .10
MCKAY BED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.															
D168897	N37E26.5-6M	1.	15.8	31.	14.	6.0	2.40	0.21	0.082	22.	0.68	0.033	< 0.10	17.	< 0.10
D168898	N37E26.5-7M	1.	8.00	26.	19.	13.	3.60	.41	.023	6.8	.43	.040	< .10	22.	< .10
D168899	N37E26.5-8M	2.	13.5	20.	11.	6.9	2.60	.25	.052	35.	.32	.059	< .10	17.	< .10
D168900	N37E26.5-9M	1.	7.65	13.	11.	11.	4.18	.42	.023	25.	.13	.063	< .10	27.	< .10
D168901	N37E26.5-10M	1.	16.9	12.	4.3	4.4	1.75	.23	.030	55.	.098	.059	< .10	11.	< .10

Table 3.--Quantitative determinations of the major, minor and trace element contents of 30 whole coal samples from four core holes in Rosebud County, Mont. [Values are in either percent or parts per million. Si, Al, Ca, Mg, Na, K, Fe, Ti, Mn, P, Cl, Cd, Cu, Li, Pb and Zn values were calculated from ash analyses. As, F, Hg, Sb, Se, Th and U values are from direct determinations on raw, ground, air dried coal. Symobls used are: -- = not looked for, < X = detected but below value shown.]

Sample No.	Field No.	Thickness of sample interval (ft)	Si%	Al%	Ca%	Mg%	Na%	K%	Fe%	Ti%	Mn%	P%	Cl%
					ROSEBUD BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.								
D168872	N46E64-1R	6.	5.0	2.2	0.58	0.30	0.024	0.15	3.6	0.061	0.0056	< 0.01	< 0.01
D168873	N46E64-2R	5.	1.4	.79	1.1	.25	.026	.0021	.31	.019	.0082	< .01	< .01
D168874	N46E64-3R	5.	1.7	.81	.84	.25	.027	.0023	.24	.034	.0063	< .01	< .01
D168875	N46E64-4R	5.	1.6	.95	.64	.21	.041	.0060	.075	.028	.0053	< .01	< .01
D168876	N46E64-5R	2.	2.8	1.7	2.4	1.4	.040	.078	2.0	.053	.019	< .01	< .01
					MCKAY BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.								
D168877	N46E64-6M	4.	1.1	1.1	0.77	0.18	0.032	0.0020	1.1	0.0071	0.0033	< 0.01	< 0.01
D168878	N46E64-7M	4.2	.62	.48	.59	.13	.055	.0064	1.7	.0041	.0020	< .01	< .01
					ROSEBUD BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R. 41 E.								
D168879	N62E62.5-1R	5.	2.9	0.84	0.79	0.24	0.016	< 0.002	0.76	0.049	0.0050	< 0.01	< 0.01
D168880	N62E62.5-2R	5.	2.8	1.0	.73	.24	.019	.092	.26	.044	.0074	< .01	< .01
D168881	N62E62.5-3R	6.	1.9	.83	.89	.26	.015	< .002	.32	.045	.0059	< .01	< .01
D168882	N62E62.5-4R	6.	1.6	.93	.79	.25	.020	.0082	.70	.043	.0051	< .01	< .01
					MCKAY BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R. 41 E.								
D168883	N62E62.5-5M	4.3	0.97	0.76	0.71	0.15	0.14	0.0031	1.0	0.018	0.0013	< 0.01	< 0.01
D168884	N62E62.5-6M	4.3	.75	.48	.60	.13	.15	.0075	3.1	.014	.0024	< .01	< .01
					ROSEBUD BED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.								
D168885	N47.5E34-1R	5.	3.5	1.5	1.3	0.25	0.015	0.25	0.51	0.053	0.0074	< 0.01	< 0.01
D168886	N47.5E34-2R	5.	1.4	.81	.97	.24	.010	< .002	.16	.030	.0063	< .01	< .01
D168887	N47.5E34-3R	5.	1.9	.66	.89	.22	.0092	< .002	1.3	.058	.0053	< .01	< .01
D168888	N47.5E34-4R	5.	.96	.64	6.5	.24	.0097	< .002	.051	.017	.0036	< .01	< .01
D168889	N47.5E34-5R	5.	2.2	1.5	.86	.22	.011	.017	.10	.049	.014	< .01	< .01
					MCKAY 8ED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.								
D168890	N47.5E34-6M	3.2	0.59	0.50	0.73	0.14	0.052	0.0085	0.88	0.011	0.0026	< 0.01	< 0.01
D168891	N47.5E34-7M	3.2	1.1	.67	.84	.15	.045	.0060	1.1	.024	.0047	< .01	< .01
					ROSEBUD 8ED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.								
D168892	N37E26.5-1R	5.	2.4	1.0	0.68	0.28	0.011	< 0.002	0.75	0.048	0.0070	< 0.01	< 0.01
D168893	N37E26.5-2R	5.	5.2	1.8	.94	.32	.019	.35	.75	.070	.0095	< .01	< .01
0168894	N37E26.5-3R	5.	1.3	.70	.84	.28	.012	.0054	.16	.043	.0049	< .01	< .01
D168895	N37E26.5-4R	5.	1.2	.80	.84	.25	.013	.0084	.21	.025	.0064	< .01	< .01
D168896	N37E26.5-5R	3.	2.8	1.3	.69	.23	.013	.0087	1.4	.056	.0048	< .01	< .01
					MCKAY 8ED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.								
D168897	N37E26.5-6M	1.	2.3	1.2	0.68	0.23	0.025	0.011	2.4	0.064	0.0033	< 0.01	< 0.01
D168898	N37E26.5-7M	1.	.97	.80	.74	.17	.024	.0015	.38	.021	.0020	< .01	< .01
D168899	N37E26.5-8M	2.	1.3	.79	.67	.21	.025	.0058	3.3	.026	.0050	< .01	< .01
D168900	N37E26.5-9M	1.	.47	.45	.60	.19	.024	.0015	1.3	.0060	.0030	< .01	< .01
D168901	N37E26.5-10M	1.	.95	.38	.53	.18	.029	.0042	6.5	.010	.0063	< .01	< .01

Table 3.--Continued.

Sample No.	Field No.	As (ppm)	Cd (ppm)	Cu (ppm)	F (ppm)	Hg (ppm)	Li (ppm)	Pb (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Zn (ppm)
ROSEBUD BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.													
D168872	N46E64-1R	3	< 0.2	16.	140	0.23	21.	10.	--	0.7			39
D168873	N46E64-2R	1	< .1	5.4	45	.13	8.6	3.7	--	.6			33
D168874	N46E64-3R	1	< .1	5.4	60	.11	14.	3.6	--	.4			24
D168875	N46E64-4R	< 1	< .1	5.2	60	.02	14.	3.1	0.3	.4			15
D168876	N46E64-5R	45	< .2	8.4	80	.64	13.	7.3	1.5	1.0			64
MCKAY BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.													
D168877	N46E64-6M	2	< 0.1	4.1	55	0.10	6.1	3.9	--	0.4			36
D168878	N46E64-7M	2	< .1	3.8	55	.11	3.0	2.5	--	.3			42
ROSEBUD BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R. 41 E.													
D168879	N62E62.5-1R	2	< 0.15	6.9	40	0.07	11.	6.0	--	0.4			24
D168880	N62E62.5-2R	< 1	< .1	6.2	55	.02	15.	3.6	--	.6			20
D168881	N62E62.5-3R	< 1	< .1	7.1	45	.06	16.	3.6	--	.3			22
D168882	N62E62.5-4R	1	< .1	5.1	45	.08	9.0	6.0	--	.7			27
MCKAY BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R 41 E.													
D168883	N62E62.5-5M	1	< 0.1	4.1	40	0.05	6.8	3.6	--	0.3			21
D168884	N62E62.5-6M	8	< .1	5.0	140	.11	3.4	3.4	--	.4			34
ROSEBUD BED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.													
D168885	N47.5E34-1R	1	< 0.15	8.8	130	0.07	19.	5.9	1.0	0.7			78
D168886	N47.5E34-2R	< 1	.1	5.2	40	.03	12.	4.5	--	.3			90
D168887	N47.5E34-3R	2	< .1	7.9	135	.19	12.	4.3	--	.3			53
D168888	N47.5E34-4R	< 1	< .2	5.6	85	.01	9.7	4.7	--	.1			29
D168889	N47.5E34-5R	1	< .1	11.	40	.04	14.	4.8	--	.7			46
MCKAY BED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.													
D168890	N47.5E34-6M	2	< 0.1	5.3	20	0.02	2.7	2.7	--	0.1			36
D168891	N47.5E34-7M	1	< .1	5.5	40	.08	6.1	2.4	--	< .1			46
ROSEBUD BED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.													
D168892	N37E26.5-1R	3	0.1	7.8	160	0.13	13.	6.3	--	0.2			75
D168893	N37E26.5-2R	5	< .2	12.	155	.26	19.	7.3	0.5	.5			49
D168894	N37E26.5-3R	1	.1	5.6	75	.13	8.4	4.3	--	.3			63
D168895	N37E26.5-4R	1	< .1	5.5	45	.04	7.2	< 2.5	--	.2			74
D168896	N37E26.5-5R	4	< .15	7.8	40	.13	14.	4.5	1.1	1.1			76
MCKAY BED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.													
D168897	N37E26.5-6M	8	< 0.15	14.	30	0.19	9.8	5.5	1.9	0.6			58
D168898	N37E26.5-7M	1	.1	5.1	< 20	.06	6.7	4.8	--	1.1			78
D168899	N37E26.5-8M	3	< .15	6.2	20	.13	5.9	5.4	--	2.1			132
D168900	N37E26.5-9M	2	.2	2.4	25	.05	2.6	2.7	--	.6			190
D168901	N37E26.5-10M	20	< .15	8.8	20	.22	1.7	4.2	2.5	1.0			85

[illegible] analyses (in ppm) for 16 trace elements in 30 samples of coal from four core holes in Rosebud County, Mont. [All values have been calculated from analyses on ash of coal. Results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc., but are reported arbitrarily as mid-points of these brackets, 1., 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of a reported value is approximately plus or minus one bracket at 68%, or two brackets at 95% confidence. Symbols used are: -- = not looked for, n.d. = not detected, < X = detected but below value shown.]

Sample No.	Field No.	Thickness of sample interval (ft)	B	Ba	Be	Co	Cr	Ca	La	Mo	Nb	Ni	Sc	Sr	V	Y	Yb	Zr
ROSEBUD BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.																		
D168872	N46E64-1R	6.	30	150	0.7	n.d.	7	5	15	2	<2	2	3	100	15	7	--	30
D168873	N46E64-2R	5.	70	300	n.d.	n.d.	2	1.5	n.d.	n.d.	n.d.	< .5	<.5	300	5	<1	<.1	15
D168874	N46E64-3R	5.	70	200	n.d.	n.d.	2	2	n.d.	<.3	n.d.	1	n.d.	200	7	<1	<.1	20
D168875	N46E64-4R	5.	100	150	.2	n.d.	3	3	7	1.5	<1	1	1	300	7	2	.2	20
D168876	N46E64-5R	2.	70	200	1.5	n.d.	3	7	n.d.	2	<2	<1	2	200	10	5	--	20
MCKAY BED (N46E64) SE 1/4 sec. 2, T. 1 N., R. 41 E.																		
D168877	N46E64-6M	4.	70	100	0.3	n.d.	1.5	2	7	1	<1	1	<.5	300	3	2	--	15
D168878	N46E64-7M	4.2	100	150	1	2	5	2	n.d.	1	<1	< .5	<.5	70	0.7	0.7	--	5
ROSEBUD BED (N62E62.5) SE 1/4 sec. 23, T. 2N., R. 41 E.																		
D168879	N62E62.5-1R	5.	70	150	0.3	n.d.	7	3	n.d.	2	<1.5	< .5	<.7	150	7	3	.3	30
D168880	N62E62.5-2R	5.	100	700	n.d.	n.d	5	2	n.d.	2	<1	1	<.5	200	7	2	.2	20
D168881	N62E62.5-3R	6.	70	1,500	n.d.	n.d.	2	2	n.d.	1	<1	1	<.5	300	5	2	.2	20
D168882	N62E62.5-4R	6.	70	300	.3	1	2	3	7	1	<1	1.5	1	200	7	3	.2	15
MCKAY BED (N62E62.5) SE 1/4 sec. 23, T. 2 N., R. 41 E.																		
D168883	N62E62.5-5M	4.3	100	700	0.2	n.d.	0.7	3	n.d.	<.3	n.d.	< .5	n.d.	200	2	<1	<.1	10
D168884	N62E62.5-6M	4.3	50	700	.5	1	1.5	2	n.d.	n.d.	n.d.	3	n.d.	200	2	2	--	7
ROSEBUD BED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.																		
D168885	N47.5E34-1R	5.	70	300	n.d.	<.7	5	5	10	<.5	n.d.	1.5	1.5	300	10	3	.5	15
D168886	N47.5E34-2R	5.	70	200	n.d.	<.5	2	3	n.d.	n.d.	2	2	< .5	300	7	<1	<.1	15
D168887	N47.5E34-3R	5.	30	100	n.d.	<.7	3	2	n.d.	1	n.d.	2	n.d.	200	5	2.	.3	20
D168888	N47,5E34-4R	5.	30	500	n.d.	n.d.	5	3	n.d.	<.5	n.d.	<1	n.d.	500	3	n.d.	n.d.	15
D168889	N47.5E34-5R	5.	50	300	0.2	n.d.	2	3	7	0.7	<1	2	<.5	200	7	2	.2	20
MCKAY BED (N47.5E34) NW 1/4 sec. 1, T. 1 N., R. 40 E.																		
D168890	N47.5E34-6M	3.2	50	200	0.7	1.5	2	2	5	0.7	<1	2	1	500	5	3	--	7
D168891	N47.5E34-7M	3.2	70	100	n.d.	n.d.	2	2	n.d.	1	n.d.	< .5	<.5	300	3	n.d.	--	15
ROSEBUD BED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.																		
D168892	N37E26.5-1R	5.	30	70	n.d.	n.d.	2	2	10	3	<1.5	1.5	<.7	30	7	2	.3	20
D168893	N37E26.5-2R	5.	70	300	n.d.	2	10	7	15	3	<2	5	2	150	15	7	.7	30
D168894	N37E26.5-3R	5.	70	20	n.d.	<.5	2	2	<5	1.5	<1	1	<.5	100	5	1.5	.15	10
D168895	N37E26.5-4R	5.	70	500	n.d.	<.5	3	3	n.d.	1.5	<1	.7	<.5	150	5	1.5	.15	15
D168896	N37E26.5-5R	3.	50	300	0.5	<.7	3	5	n.d.	2	<1.5	< .7	<.7	100	7	5	--	20
MCKAY BED (N37E26.5) NE 1/4 sec. 15, T. 1 N., R. 40 E.																		
D168897	N37E26.5-6M	1.	50	20	0.7	n.d.	1.5	5	n.d.	1	<1.5	<.7	n.d.	300	5	5	--	30
D168898	N37E26.5-7M	1.	50	500	n.d.	<.5	1	2	n.d.	n.d.	<1	<.5	<.5	200	1.5	1.5	.3	10
D168899	N37E26.5-8M	2.	50	1,000	n.d.	n.d.	1.5	3	n.d.	1.5	n.d.	<.7	n.d.	200	3	n.d.	--	10
D168900	N37E26.5-9M	1.	70	10	.2	<.5	.7	2	n.d.	.7	n.d.	1.5	n.d.	150	2	1.5	--	3
D168901	N37E26.5-10M	1.	30	30	2	3	3	5	n.d.	3	n.d.	5	2	300	3	7	--	10

APPENDIX F3

Gross Uranium, Gross Thorium and Radium-226 Content
In Rosebud Coal Seam (A) and McKay Seam (B)
A

Sample Number	Location	Uranium (ug/g)	Thorium (ug/g)	Radium-226 (pCi/gm)
1	Hole N50 E62	0.8	2.4	0.3
2	Hole N45 E65	1.4	2.9	0.3
3	Hole N43 E69	1.1	2.3	0.3
4	Hole N49 E60	1.1	2.6	0.3
5	Hole N46 E64	1.0	2.0	0.3
9	Hole N45 E68	1.4	2.0	0.3
10	Hole N48 E64	0.8	2.0	0.3
11	Pit No. 6 (8 ft. depth)	0.2	1.8	0.2
12	Pit No. 6 (20 Ft. depth)	1.8	3.8	0.3
13	Hole N44 E19	1.4	2.4	0.7
14	Hole N46 E15	1.8	1.8	0.6
15	Hole N48 E34	1.1	2.5	0.4
16	Hole N62 E61	0.8	2.7	0.2
17	Hole N36 E63	1.3	3.1	0.4
18	Pit-6-A-12 Extension	0.8	3.1	0.4
19	Hole N44 E31	0.9	2.7	0.4
20	Hole N38 E37	0.9	2.5	0.4
21	Hole N37 E62	2.0	4.3	0.5
22	Hole N61 E60	1.2	2.4	0.2
23	Hole N39 E36	1.2	3.0	0.2
24	Hole N65 E64B	0.5	2.5	0.2
25	Hole N63 E62	1.0	1.9	0.2
26	Hole N64 E63	0.7	2.3	0.2
mean =		1.1	2.57	0.33

APPENDIX F3 (Continued)

Gross Uranium, Gross Thorium and Radium-226 Content In Rosebud Coal Seam (A) and McKay Seam (B)

B

Sample Number	Location	Uranium (ug/g)	Thorium (ug/g)	Radium-226 (pCi/gm)
6	Hole N43 E68	0.7	1.8	0.1
7	Hole N46 E66	1.0	2.0	0.4
8	Hole N45 E64	0.2	1.4	0.2
27	Hole N47 E38	0.7	2.6	0.3
28	Pit-A-12 Extension	0.7	3.0	0.2
29	Hole N65 E60	0.9	2.3	0.3
30	Hole N61 E62	0.8	2.6	0.3
31	Hole N38 E37	1.0	2.8	0.2
mean =		0.75	2.31	0.25

Source: Occupational Health Bureau, HES

F4: Trace Element Analyses of Rosebud Coal Performed by Montana State University.

TABLE 1

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Antimony Analyses

Non-flame atomic absorption analyses were performed for antimony on January 16, 17 and 18.
The sensitivity of the method is 1 x 10^{-11} grams. The working detection limit (50 microliter sample) is 0.02 ppm in the coal.

Sample	Concentration ppm	Sample	Concentration ppm
25779	1.80	26123	0.31
25780	0.20	26124	0.12
25781	0.45	26125	0.31
25782	0.22	26126	0.23
25783	<0.06	26127	0.25
25784	0.25	26128	0.42
25785	0.77	26306	0.30
25991	0.12	26307	0.25
25992	0.16	26308	0.38

TABLE 1 (cont)

Sample	Concentration ppm	Sample	Concentration ppm
25993	0.22	26309	0.28
25994	0.14	26310	0.50
25995	0.25	26541	0.85
25996	0.94	26542	0.48
25997	0.37	26543	0.56
25998	1.13	26544	0.26
26121	0.62	26545	0.66
26122	0.89		

TABLE 2

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Arsenic Analyses

Non-flame atomic absorption analyses were performed for arsenic on October 11 through 36, 1973.

Sensitivity of the method is 2.5 x 10^{-11} grams.

The working detection limit is 0.16 micrograms per gram of coal.

Sample	Concentration μg/g coal	Sample	Concentration μg/g coal
25779	0.62	26123	3.61
25780	2.69	26124	4.36
25781	2.69	26125	4.75
25782	3.53	26126	3.44
25783	11.15	26127	3.12
25784	0.62	26128	8.34
25785	6.18	26306	3.62
25991	3.88	26307	4.18
25992	3.14	26308	2.50

TABLE 2 (cont)

Sample	Concentration µg/g coal	Sample	Concentration µg/g coal
25993	2.63	26309	6.25
25994	3.69	26310	13.75
25995	1.86	26541	11.59
25996	8.30	26542	5.51
25997	5.44	26543	4.81
25998	4.05	26544	5.84
26121	2.48	26545	16.46
26122	5.60		

TABLE 3

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Beryllium Analyses

Non-flame atomic absorption analyses were performed for beryllium on June 6 through June 12, 1973.

Sensitivity of the method is 5×10^{-12} grams.

The detection limit expressed as micro grams per gram of coal is 0.05 ug/g.

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25779	0.50	26123	0.40
25780	0.12	26124	0.22
25781	0.12	26125	0.20
25782	0.22	26126	0.10
25783	1.75	26127	0.31
25784	0.50	26128	1.09
25785	1.19	26306	0.20
25991	0.20	26307	0.10
25992	0.10	26308	0.10
25993	0.19	26309	0.22
25994	0.24	26310	1.14

TABLE 3 (cont)

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25995	0.31	26541	0.52
25996	1.40	26542	0.10
25997	0.11	26543	0.10
25998	1.41	26544	0.20
26121	1.01	26545	0.45
26122	0.96		

TABLE 4

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Cadmium Analyses

Non-flame atomic absorption analyses were performed for cadmium on May 11 and 14, 1973.

Sensitivity of the method is 5×10^{-13} grams.

The detection limit expressed as micro grams per gram of coal is 0.005 ug/g.

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25779	0.151	26123	0.025
25780	1.065	26124	0.074
25781	0.586	26125	0.025
25782	0.137	26126	0.097
25783	0.350	26127	0.151
25784	0.050	26128	0.469
25785	0.114	26306	0.059
25991	0.294	26307	0.197
25992	0.446	26308	0.044
25993	0.692	26309	0.184
25994	0.451	26310	0.395
25995	0.226	26541	0.346

TABLE 4 (cont)

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25996	0.274	26542	0.100
25997	0.098	26543	0.149
25998	0.074	26544	0.249
26121	0.076	26545	0.422
26122	0.096		

TABLE 5

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Chromium Analyses

Non-flame atomic absorption analyses were performed for chromium on September 28 and October 1, 1973.
Sensitivity of the method is 1.5×10^{-10} grams.
The detection limit is 0.37 micrograms per gram of coal.

Sample	Concentration µg/g coal	Sample	Concentration µg/g coal
25779	1.99	26123	28.60
25780	6.88	26124	1.25
25781	1.91	26125	1.25
25782	3.96	26126	1.87
25783	<0.37	26127	1.50
25784	<0.37	26128	10.66
25785	1.98	26306	1.25
25991	1.88	26307	1.25
25992	<0.37	26308	1.25
25993	1.86	26309	1.25
25994	<0.37	26310	2.25

TABLE 5 (cont)

Sample	Concentration µg/g coal	Sample	Concentration µg/g coal
25995	3.23	26541	5.26
25996	4.35	26542	3.13
25997	0.50	26543	13.50
25998	<0.37	26544	1.24
26121	10.54	26545	5.22
26122	2.24		

TABLE 6

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Copper Analyses

Samples were analyzed for copper by non-flame atomic absorption spectroscopy on March 22 and 25, 1974.
The sensitivity of the method is 2×10^{-10} grams copper.
The working detection limit for a 50 microliter sample is 0.5 ppm in the coal.

Sample	Concentration ppm	Sample	Concentration ppm
25779	7.2	26123	9.4
25780	9.5	26124	6.0
25781	7.9	26125	6.7
25782	10.9	26126	7.6
25783	9.9	26127	8.0
25784	8.2	26128	7.5
25785	11.1	26306	8.3
25991	9.8	26307	7.2

TABLE 6 (cont)

Sample	Concentration ppm	Sample	Concentration ppm
25992	7.0	26308	10.0
25993	7.0	26309	4.2
25994	10.7	26310	10.0
25995	10.2	26541	14.7
25996	8.2	26542	8.0
25997	6.2	26543	9.5
25998	5.2	26544	4.7
26121	6.4	26545	11.4
26122	9.7		

TABLE 7

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Fluoride Analyses

Coal samples were prepared for analysis by acid-pressure digestion (Parr acid digestion bomb) during December 1973 and the fluoride concentrations analyzed with a specific ion electrode on January 8-10, 1974.

The working detection limit is 5.0 ± 0.5 ppm (10^{-6} gF^-/g coal) in the samples.

Sample	Concentration ppm	Sample	Concentration ppm
25779	14.0	26123	10.5
25780*	20	26124	10.0
25781	5.0	26125	15.5
25782	15.0	26126	18.0
25783	13.0	26127*	20
25784	5.0	26128	10.0
25785	13.0	26306	11.5
25991	5.0	26307	16.5
25992	19.0	26308*	20
25993	13.0	26309	5.5
25994	12.0	26310	6.5

TABLE 7
(continued)

Sample	Concentration ppm	Sample	Concentration ppm
25995	5.0	26541	7.5
25996	5.0	26542	5.0
25997	14.5	26543	5.5
25998	10.5	26544*	20
26121	10.5	26545	10.5
26122	14.5		

*Values for samples denoted by asterisks are somewhat doubtful; 20 ppm represents the best value available. Samples will be reanalyzed with the next coal samples.

TABLE 8

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Germanium Analyses

Non-flame atomic absorption analyses were performed for germanium on January 23, 24 and 25.

The sensitivity of the method is 6 x 10^{-11} grams. The working detection limit (50 microliter sample) is 0.15 ppm in the coal.

Sample	Concentration ppm	Sample	Concentration ppm
25779	0.4	26123	0.4
25780	3.0	26124	1.2
25781	1.3	26125	0.4
25782	0.8	26126	2.0
25783	0.3	26127	0.2
25784	0.5	26128	1.2
25785	3.4	26306	1.6
25991	0.3	26307	2.3
25992	1.4	26208	0.8
25993	0.3	26309	2.1
25994	1.3	26310	1.4

TABLE 8 (cont)

Sample	Concentration ppm	Sample	Concentration ppm
25995	2.5	26541	0.3
25996	3.1	26542	0.3
25997	0.3	26543	0.9
25998	0.5	26544	0.2
26121	1.7	26545	0.7
26122	2.1		

TABLE 9

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Lead Analyses

Non-flame atomic absorption analyses were performed for lead on April 30 and May 4, and 7, 1973

Sensitivity of the method is 2×10^{-12} grams.

The detection limit expressed as micro grams per gram of coal is 0.02 ug/g.

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25779	5.04	26124	3.32
25780	4.36	26125	3.58
25781	2.44	26126	3.51
25782	7.72	26127	29.77
25783	5.00	26128	5.55
25784	1.37	26306	2.79
25785	8.25	26307	2.79
25991	5.53	26308	6.06
25992	4.25	26309	5.42
25993	6.06	26310	5.14

TABLE 9 (Cont)

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25994	7.14	26541	6.14
25995	2.77	26542	11.39
25996	4.11	26543	4.18
25997	1.60	26544	2.81
25998	1.61	26545	7.03
26121	6.05		
26122	2.03		
26123	2.74		

TABLE 10

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Manganese Samples

Non-flame atomic absorption analyses were performed for manganese on May 23, 25, and 28, 1973.

Sensitivity of the method is 3×10^{-11} grams.

The detection limit expressed as micro grams per gram of coal is 0.3 ug/g.

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25779	82.2	26123	58.8
25780	56.2	26124	117.2
25781	85.5	26125	370.6
25782	131.9	26126	140.8
25783	170.6	26127	134.7
25784	37.4	26128	152.0
25785	24.4	26306	67.7
25991	49.1	26307	80.0
25992	62.4	26308	83.0
25993	127.5	26309	80.6
25994	58.1	26310	49.4
25995	155.1	26541	83.1

TABLE 10(cont.)

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25996	118.6	26542	82.6
25997	116.4	26543	87.1
25998	44.7	26544	111.9
26121	91.3	26545	130.1
26122	55.5		

TABLE 11

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Mercury Analyses

Non-flame atomic absorption analyses were performed for mercury on July 21, 1973.
Sensitivity of the method is 5 x 10^{-10} grams.
The detection limit expressed as micrograms per gram of coal is 0.01 μg/g.

From Pit 6 and Area E

Sample	Concentration μg/g coal	Sample	Concentration μg/g coal
25779	0.25	26123	0.17
25780	0.32	26124	0.27
25781	0.21	26125	0.09
25782	0.11	26126	0.09
25783	0.38	26127	0.11
25784	0.25	26128	0.22
25785	0.23	26306	0.25
25991	0.14	26307	0.10
25992	0.10	26308	0.13
25993	0.08	26309	0.07
25994	0.14	26310	0.29

TABLE 11 (cont)

Sample	Concentration µg/g coal	Sample	Concentration µg/g coal
25995	0.09	26541	0.56
25996	0.53	26542	0.10
25997	0.11	26543	0.14
25998	0.19	26544	0.11
26121	0.24	26545	0.28
26122	0.25		

TABLE 12

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Nickel Analyses

Non-flame atomic absorption analyses were performed for Nickel on June 22 through June 27, 1973.

Sensitivity of the method is 2×10^{-9} grams.

The detection limit expressed as grams per gram of coal is 1.5 ug/g.

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25779	41.9	26123	17.4
25780	38.7	26124	24.6
25781	39.2	26125	12.4
25782	48.2	26126	19.4
25783	62.0	26127	13.6
25784	_2.5	26128	39.0
25785	48.6	26306	14.8
25991	61.4	26307	4.9
25992	149.8	26308	1.5
25993	61.8	26309	6.0
25994	22.5	26310	38.5
25995	42.3	26541	24.7

TABLE 12 (cont)

Sample	Concentration ug/g coal	Sample	Concentration ug/g coal
25996	67.3	26542	12.5
25997	44.2	26543	3.5
25998	67.1	26544	1.5
26121	28.2	26545	39.7
26122	41.6		

TABLE 13

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Selenium Analyses

Non-flame atomic absorption analyses were performed for selenium on August 13 through August 31, 1973.
Sensitivity of the method is 5×10^{-11} grams.
The detection limit expressed as micrograms per gram of coal is 0.06 μg/g.

Sample	Concentration μg/g coal	Sample	Concentration μg/g coal
25779	1.41	26123	1.06
25780	5.14	26124	1.33
25781	<0.06	26125	0.62
25782	<0.06	26126	2.03
25783	<0.06	26127	0.81
25784	0.69	26128	2.59
25785	0.37	26306	1.07
25991	1.94	26307	1.18
25992	1.15	26308	1.40
25993	1.43	26309	1.31

TABLE 13 (cont)

Sample	Concentration µg/g coal	Sample	Concentration µg/g coal
25994	1.27	26310	2.58
25995	1.33	26541	2.96
25996	1.98	26542	2.33
25997	3.63	26543	0.98
25998	1.42	26544	2.30
26121	0.42	26545	2.70
26122	2.04		

TABLE 14

WESTERN ENERGY COAL SAMPLES
Analyzed by Montana State University (MSU)
Zinc Analyses

Samples were analyzed for zinc by atomic absorption spectroscopy on March 8, 15, and 19, 1974.

The sensitivity of the method is 8×10^{-10} grams zinc.

The working detection limit for a 50 microliter sample is 2.0 ppm zinc in the coal.

Sample	Concentration ppm	Sample	Concentration ppm
25779	17.4	26123	19.9
25780	27.5	26124	8.7
25781	28.6	26125	12.5
25782	30.2	26126	11.7
25783	32.2	26127	18.7
25784	17.5	26128	15.0
25785	26.0	26306	52.4
25991	31.2	26307	7.5
25992	11.5	26308	6.2

TABLE 14 (cont)

Sample	Concentration ppm	Sample	Concentration ppm
25993	12.4	26309	10.7
25994	>5.2	26310	41.3
25995	30.3	26541	10.0
25996	13.5	26542	>8.8
25997	20.0	26543	10.7
25998	14.9	26544	46.5
26121	11.7	26545	99.5
26122	13.7		

APPENDIX G: LAND USE

TABLE 1

LAND USE - 1958 AND 1967

County	Total Land Area	Federal Non Cropland		Urban and Built-up		Small Water Areas		Cropland	
		1958	1967	1958	1967	1958	1967	1958	1967
Big Horn	3,217,626	33,662	32,062	10,827	11,979	676	700	298,021	286,480
Custer	2,409,600	354,013	344,689	12,807	14,307	9,084	9,084	126,349	92,185
Garfield	2,940,800	752,455	670,929	34,111	16,388	2,000	3,000	119,500	138,000
Musselshell	1,207,040	123,410	117,930	13,822	14,100	1,485	1,485	71,460	62,905
Petroleum	1,056,000	394,543	358,294	9,143	9,143	359	359	38,481	36,888
Powder River	2,102,400	593,927	604,101	6,139	6,200	1,600	1,600	133,173	150,970
Prairie	1,105,280	451,054	450,078	8,818	8,818	919	1,028	117,903	113,030
Rosebud	3,220,480	337,773	337,995	4,608	5,208	3,104	3,104	128,496	128,303
Treasure	629,760	11,378	11,694	3,118	4,115	1,185	1,185	59,428	37,768
Yellowstone	1,686,400	93,835	85,230	41,033	44,333	470	500	307,806	284,816

Source: U.S.D.A. 1970

TABLE 1
(continued)

County	Pasture 1958	Pasture 1967	Range 1958	Range 1967	Forest 1958	Forest 1967	Other 1958	Other 1967
Big Horn	4,545	42,430	2,663,389	2,501,257	200,000	331,721	10,000	10,997
Custer	7,606	27,600	1,870,862	1,857,135	22,000	56,500	6,879	8,100
Garfield	40,000	40,000	1,948,080	2,019,602	38,000	41,381	6,654	11,500
Musselshell	17,828	24,505	732,168	733,882	241,000	242,405	5,867	9,828
Petroleum	6,312	10,765	575,899	615,557	23,939	21,530	7,449	3,464
Powder River	8,000	30,000	1,287,386	1,218,201	67,000	85,528	5,175	5,800
Prairie	6,165	15,000	512,539	510,041	2,000	1,785	5,882	5,500
Rosebud	17,388	27,388	2,612,225	2,483,906	103,000	220,690	13,886	13,886
Treasure	40,783	8,127	487,813	523,289	24,000	38,603	2,055	4,979
Yellowstone	4,333	71,000	1,162,863	1,101,889	56,000	78,501	20,000	20,131

Source: U.S.D.A. 1970

TABLE 2

ACREAGES AND PRODUCTION OF ALL CROPS,
IRRIGATED AND NOT IRRIGATED - 1971

Acres Harvested and Value of Crop Production

County	IRRIGATED		NOT IRRIGATED	
	Acres Harvested	Value of Crop Production	Acres Harvested	Value of Crop Production
Big Horn	34,910	$ 2,317,300	122,400	$ 4,404,300
Custer	17,300	1,888,000	48,500	1,330,600
Garfield	3,405	154,400	71,200	1,855,700
Musselshell	8,030	475,400	30,100	763,000
Petroleum	13,600	773,900	13,300	334,100
Powder River	14,305	503,100	83,000	2,412,900
Prairie	6,315	895,100	56,800	1,654,600
Rosebud	26,860	2,009,700	52,600	1,566,400
Treasure	11,370	1,929,500	12,600	399,900
Yellowstone	38.590	6.182,500	121.500	4.175.800

Source: Montana Crop and Livestock Reporting Service 1972

TABLE 3

AVERAGE YIELDS OF CULTIVATED CROPS, 1971

County	Wheat		Barley		Oats		Corn[3]		Rye	
	Acres[1]	Y/A[2]	Acres[1]	Y/A[2]	Acres[1]	Y/A[4]	Acres[1]	Y/A[4]	Acres[1]	Y/A[2]
Big Horn	56,800	30.2	25,500	41.0	4,400	37.7	3,000	16.0	100	19.0
Custer	13,500	26.2	4,600	24.7	4,000	37.8	1,300	15.0	-0-	-0-
Garfield	30,400	22.4	10,000	29.0	5,400	29.0	400	15.0	-0-	-0-
Musselshell	11,500	24.8	7,200	27.4	600	36.5	400	16.0	100	25.0
Petroleum	4,200	25.3	1,500	30.1	1,600	30.0	-0-	-0-	-0-	-0-
Powder River	22,200	29.9	3,500	28.2	5,700	38.8	100	13.0	-0-	-0-
Prairie	35,500	28.9	7,200	27.4	3,600	40.9	2,100	13.0	-0-	-0-
Rosebud	17,300	28.2	14,600	42.1	4,100	46.9	1,300	15.0	-0-	-0-
Treasure	4,100	30.6	2,300	57.7	400	75.0	1,600	18.0	-0-	-0-
Yellowstone	77,100	30.4	39,500	40.0	2,400	53.0	10,600	18.0	-0-	-0-

TABLE 3
(continued)

County	Beans		Potatoes		Sugarbeets		All Hay	
	Acres[1]	Y/A[5]	Acres[1]	Y/A[6]	Acres[1]	Y/A[4]	Acres[1]	Y/A[4]
Big Horn	1,200	12.8	-0-	-0-	-0-	-0-	63,300	1.89
Custer	100	16.0	-0-	-0-	1,780	23.2	39,100	1,82
Garfield	-0-	-0-	-0-	-0-	-0-	-0-	28,200	1.07
Musselshell	-0-	-0-	-0-	-0-	-0-	-0-	18,200	1.34
Petroleum	-0-	-0-	-0-	-0-	-0-	-0-	17,800	1.67
Powder River	-0-	-0-	-0-	-0-	-0-	-0-	62,500	1.18
Prairie	200	16.0	-0-	-0-	1,710	19.7	14,000	1.41
Rosebud	-0-	-0-	-0-	-0-	1,560	18.1	38,800	1,82
Treasure	900	15.8	-0-	-0-	3,870	22.7	10,900	1.62
Yellowstone	1,400	15.8	-0-	-0-	12,490	20.8	26,600	2.53

1-Acres harvested
2-Yield per acre--bushels
3-Irrigated silage only
4-Yield per acre--tons
5-Yield per acre--100 pound bags (cleaned)
6-Yield per acre--Cwt (hundred weight)

Source: Montana Crop and Livestock Reporting Service 1972

TABLE 4

LIVESTOCK PRODUCTION, 1971

Number of Head

County	Cattle	Sheep	Hogs
Big Horn	125,000	10,500	11,900
Custer	93,000	30,000	2,100
Garfield	80,000	94,000	1,100
Musselshell	42,000	18,000	2,300
Petroleum	33,000	11,000	900
Powder River	85,000	50,000	300
Prairie	43,000	9,500	3,900
Rosebud	99,000	25,000	3,300
Treasure	33,000	4,000	1,400
Yellowstone	132,000	15,000	3,000

Source: Montana Crop and Livestock Reporting Service 1972

TABLE 5

SUBDIVIDED LAND (Incomplete)

County	Acres Subdivided
Big Horn	661
Custer	17,876
Garfield	*
Musselshell	33,031
Petroleum	*
Powder River	*
Prairie	*
Rosebud	454
Treasure	*
Yellowstone	18,646

* No data available

Source: Environmental Information Center 1974

TABLE 6

MONTANA POWER SCHEDULED ELECTRIC TRANSMISSION LINES

	1974	1975	1976	1977	1978	1979
Billings-Great Falls 230 KV Line	xxxxx	xxxxx				
Broadview-Alkali Creek 230 KV Line	ss	xxxxx				
Colstrip-Nichols 115 KV Line	xxxxx					
Billings-Continental Oil 100 KV Loop Line	ss	xxxxx				
Laurel-Billings 8th St. 100 KV Line	xxxxx					
Billings-Roundup 100 KV Line			ss	xxxxx		

ss - Indicates date of survey work
xxxxx - Indicates date of construction

Source: Montana Power Company 1974

APPENDIX H: Social Impact

H1 Methodology of the Ethnographic Study of Social Impact

The purpose of the ethnographic study reported in Section 11.2.2.2. was to determine what difference the Colstrip generating plants and other coal-related developments are making in the lives of residents of southeastern Montana. While this difference could have been investigated from a variety of viewpoints (e.g., coal company officials', bureaucrats', politicians', urban America's, and so on), the researchers chose to study it from the points of view of the residents of the study area for reasons elaborated below. Having made this decision, the next major research question concerned how these desired points of view could best become known. Max Weber, the famous social scientist claimed by anthropologists, sociologists, economists, and political scientists, argued that in order to understand human society the social scientist is obliged to study it without wittingly or unwittingly imposing his own views (or the views of professional, scientific, or religious authorities, among others) upon whatever process he may use to gather, analyze, and report data (Weber 1947).[1] Weber concluded that one could best understand society for what it is (not for what one thinks it might, should, must, will be, etc.) by learning how to study it from the points of view of society's members. Early in the present century, Weber developed a theoretical and methodological rationale for ethnography which he called "verstehende soziologie." A fair translation is "a sociology of knowing" or a "sociology of meaning." The ethnographic method of research was well suited to carrying out this approach to studying society because it put the researcher into close and continuing contact with those being studied and thereby enabled him to minimize his natural human tendencies to be blinded by his own life-style (i.e., to be "ethnocentric") when trying to become intimately acquainted with the society and culture (i.e., life-style) of his research subjects. Verstehende sociology is a firm, useful, and desirable foundation for ethnographic fieldwork because it minimizes tendencies to wear ethnocentric blinders when trying to understand what life is like to those being studied.

The decision to study southeastern Montana in the verstehende sociological

manner was made because this approach fits exactly the primary requirement of social impact research: to investigate what difference the impact makes to and in the lives of people in the study area and, for the purposes of this project, to do so primarily from their points of view. This implies that the researcher must avoid any inclination to get hung up on the usual statistical analyses of human behavior because, among other reasons, the people whose point of view he is trying to comprehend are not at all likely to know their social world in terms of numerical indices or measures. For example, the established residents in Forsyth, Montana tend to avoid most of the local bars because there has been some violence and other unpleasantness and tenseness in these establishments since certain groups of Colstrip construction workers began frequenting these bars. The locals' definition of the situation is widespread (it includes among its adherents the bars' formal rural customers no less than city ones): to use the words of several residents, it is no longer safe, relaxing, enjoyable, and the like to go to most of Forsyth's bars, especially with your wife or date. It is better to go to the local country club or to Miles City's bars. Little is learned about social impact when it is found that, as a matter of fact, only a small number of construction workers (they are mostly men in one building trade whose members are trying to maintain their national reputation as "good drinkers" and "barroom brawlers") rather than construction workers in general are responsible for the alleged violence and other unpleasantness. Counting such externals as the number of construction workers who fight and cast insults loudly in bars, the frequency with which they so behave, and the like perhaps means something to the researcher who does the counting; and he may report that the great majority of construction workers are really fine fellows and that only a small number are the "real trouble-makers." This kind of reporting is what Weber wanted social scientists to play down because it does not address the critical question of <u>what the situation means</u> to those concerned. It is social fact that the locals define the tavern situation in Forsyth as having been made unwelcome by Colstrip's construction workers, and this reality, not the reality of a counter of externals, is what has to be reported and dealt with when seeking to know this social impact as those being studied perceive it, find meaning in it, remember it, and hence know it.[2] In other words, the authors of this report are concerned with understanding the social realities of the study area's research subjects, not with the realities suggested by counting instances of that which is arbitrarily categorized by investigators

who eschew ethnography or ethnomethods in general.[3]

Finding and understanding the reality of people who are experiencing social impact is a difficult task which is made still more difficult when, as in the case of southeastern Montana, the social processes at work are complicated and clouded by ever-present uncertainties, ambivalences, rumors, and many similar social ingredients which somehow combine to keep people off balance and wondering if anything in the world is really and truly what it seems to be. As the researcher gradually gains knowledge of the processes at work as informants perceive and define emergent and ongoing situations, and hence construct social realities, he grows increasingly capable of projecting images of the future. Residents of the study area create images of the future through defining coal-related situations and imagining how these situations will develop and affect them over time, and acting so as to protect their interests in light of what they prophesy; they thus tend to create aspects of the future through hedging and other protective actions which become self-fulfilling prophecies.[4] For example, ranchers who lease surface rights to land developers say they are doing so to protect themselves against an uncertain future course of industrialization. Ironically, even though these ranchers have a strongly anti-development attitude, they are actually tending to make industrialization of coal resources more feasible for land developers and their industrial clients. The irony of all this is not lost upon these ranchers. In interviews they spoke often of how they may well be contributing to the creation of an unwanted future. They find that they are risking entrapment in self-fulfilling prophecies whose outcomes may be much less protective of their interests than they had imagined when they first leased some coal-bearing land. An important point to be made here is that, as noted above, ethnographic data on present social impact can be very useful for predicting the likely social effects of given coal-industrial-developmental modalities.

Data generated through using ethnomethods, such as ethnography, reveal not only how to make better predictions concerning what the future social impacts will be but also how to assess (including future statistical measurements of) the intensity, degree, or size of present impacts and to predict the kind and amount of future impacts. The difficulty of this method is to get close enough to the people being studied to know how their self-fulfilling prophecies make definitions of situations seem to come true in both kind and degree. Natural or "folk" measurement is in fact now being

done by people in the study area as they form collective definitions of degree of impact of a variety of things, ranging from what will happen to them if land is leased (leading to industrialization and large influxes of people whose very number, rural informants believe, would be incompatible with ranching) to what will happen to ground water if strip mining is done. Some of these things can be influenced by the informants, others not; the former are now being affected by the informants' definitions of situations and attendant self-fulfilling prophecies pertaining to degree as well as to kind of impact.

For the present research, studying social impact using a verstehende sociological approach to fieldwork required that the researcher strive to look at the social world from the point of view of those whose world is being impacted by coal-related developments. He must deliberately suppress most tendencies to speak for himself or in any way to inject his views into informants' accounts. Thus, when he reports what his informants told him about the past, present, and future, he is trying to be faithful to their social world as they experience it, even using their terms and natural language expressions to help describe and document more clearly their understanding of what they do (and do not) take into account and how they do so, how they find meanings in this accounting, and what they define as the individual and collective consequences of all these social practices.

Not all informants are good at the task asked of them; not all are able and/or willing to provide insightful, coherent, and lucid descriptions of what has been (or will be) happening to them as coal developments get under way in various forms and at given rates. An occasional informant may be (and almost always in fact is) astoundingly articulate, seemingly able and willing to say loudly and clearly what many others like him say less well or not at all. To learn what the less articulate informants "know" about what is happening to and around them the researcher returns to some to try out on them what he thinks he has come to know as a result of interviewing one or more of their especially articulate fellows. The usual response is: "Yeah, that's what I meant but I didn't know how to explain it to you," or, "No, that's not exactly what I meant. What I meant was..." and here follows a much clearer account than the informant was able to give when first asked the question (s). The researcher then continues checking with informants until he establishes that there

is or is not consensus on what is happening in or to whatever he is inquiring about, or that perhaps he misclassified some informants and needs to refine his classification of them or of their attitudes and actions in order to account for seemingly deviant cases, and so on. Also, he continually tries out his attempts on them in order to get them to agree or disagree with his understanding of their accounts and to correct him where they reckon he is mistaken. All the while he is attempting to perceive and understand the changing social world of the informants as they do.

The ethnographer's ongoing assumption is that people in the social scene being studied are the ultimate authorities concerning what is happening there and what it all means to them and others around them. If, for example, the people of a community say that social stratification has been subtle and played down in any overt sense because they value and share a strong egalitarian commitment, then this is their reality and it must be respected if one is to understand them as they understand themselves. In Thomas's famous words, "If the individual defines the situation as real, it is real in its consequences" (Thomas and Znaniecki 1918-1920). The individual's reality and its consequences for him and his friends and neighbors are accordingly of paramount interest to the researcher. How this reality and its consequences come about, what it means to the individual and his fellows in terms of attitudinal development and behavioral expression, and the like are matters the researcher continually seeks to understand as the actors themselves understand them in their dynamic, changing situation.

A brief word about the relationship between attitudes and actions is in order, mainly because the depictions of informants so far have been much more in terms of their attitudes than their actions; very little has been said to this point about what they have done, are doing, or are likely to do in consequence of having certain attitudes toward coal and power plant development. After literally thousands of studies of people's attitudes toward all manner of things, social scientists have convincingly demonstrated that there is little or no necessary relationship between attitudes and actions. This means, among other things, that one cannot safely predict how a person with a very strong and persistent attitude toward something is going to act toward it, given the opportunity to do so. In the present research, for example, it was found that some landowners who definitely oppose coal development are leasing or selling coal-bearing land to land developers or directly to

energy companies; some such landowners are not at all tempted to sell or lease any of their land but are acting so as to foster some kind of workable accommodation to coal development; other such landowners are actively fighting off those who seek to develop coal resources anywhere in the vicinity of their farms and ranches.

Sociological Sampling

It makes an enormous difference whether the purpose of one's sampling design is to permit the researcher to identify and obtain information from individuals with a view to securing data which are likely to be similar to what could be secured if all of the sample's parent population were contacted, or if the purpose of the design is to permit informants to participate in the actual sampling through telling the researcher how to locate and interview persons whose social roles, relationships, situations, desires, needs, and the like are representative of the human behavior that the researcher is interested in investigating. The first kind of sampling is based on the assumption that nothing is known about the population to be studied and that probability sampling must be used to keep the investigation from making too many mistakes in finding and selecting respondents. This is conventional, statistical sampling, the kind ordinarily used in survey research. It has the advantage of providing the researcher with assurance that he can count, compare, examine relationships, and measure research variables with considerable precision. It is not suited to research which aims to discover how informants classify or label each other, how they find meaning in activities they care about in life, how they engage in processes in which they individually and collectively define the coal development situation and its impact upon their society and themselves, and related matters such as those the present case study is attempting to investigate. Rather, it is most useful only after the researcher has clearly classified and categorized his data and wishes then to find out how many cases he has in each category of behavior, or what the precise distribution of attitudes of a given sort is among the population under study, or the like. To sample a population with the intention of quickly and inexpensively learning, for example, what the several social groupings of the study area's residents are like from the standpoint of each grouping's members and from those of neighbors, friends, relatives, and community officials who know them, and so on, the second kind of sampling must be used. This sampling approach is what the distinguished researchers Glaser and Strauss call "theoretical

sampling" because its purpose is to generate new knowledge of theoretical importance, revealing the basic variables at work in the members' daily situations (and hence of importance for succeeding in planning and programming efforts)(Glaser and Strauss 1967).

Theoretical and sociological sampling are both verstehende sociological in principal and general thrust. Both attempt to sample with a view to depicting the social situation being studied as people in the situation view it. The main difference between the two is that the focused objective of theoretical sampling is to generate theory, while that of sociological sampling is to generate empirically sound descriptions of how the research subjects perceive and experience that which is under study (in the present case, social impact of power generating plants).

Glaser and Strauss (1967, pp 62-65) contrast theoretical sampling with statistical sampling, which is based on probability theory. Their discussion of the difference helps explain the decision to use the kind of sampling chosen for the present project.

> It is important to contrast theoretical sampling based on the saturation of categories with statistical (random) sampling. Their differences should be kept clearly in mind for both designing research and judging its credibility. Theoretical sampling is done in order to discover categories and their properties, and to suggest the inter-relationships into a theory. Statistical sampling is done in order to obtain accurate evidence on distribution of people among categories to be used in descriptions or verifications. Thus, in each type of research the "adequate sample" that we should look for (as researchers and readers of research) is very different.
>
> The adequate theoretical sample is judged on the basis of how widely and diversely the analyst chose his groups for saturating categories according to the type of theory he wished to develop. The adequate statistical sample, on the other hand, is judged on the basis of techniques of random and stratified sampling used in relation to the social structure of a group or groups sampled. The inadequate theoretical sample is easily spotted, since the theory associated with it is usually thin and not well inte-

grated, and has too many obvious unexplained exceptions. The inadequate statistical sample is often more difficult to spot; usually it must be pointed out by specialists in methodology, since other researchers tend to accept technical sophistication uncritically.

The researcher who generates theory need not combine random sampling with theoretical sampling when setting forth relationships among categories and properties. These relationships are suggested as hypotheses pertinent to direction of relationships, not tested as descriptions of both direction and magnitude. Conventional theorizing claims generality of scope; that is, one assumes that if the relationship holds for one group under certain conditions, it will probably hold for other groups under the same conditions. . . . This assumption of persistence is subject only to being disproven--not proven--when other sociologists question its credibility. Only a reversal or disappearance of the relationship will be considered by sociologists as an important discovery, not the rediscovery of the same relationship in another group; since once discovered, the relationship is assumed to persist. Persistence helps to generalize scope but is usually considered uninteresting, since it requires no modification of the theory.

Furthermore, once discovered the relationship is assumed to persist in direction no matter how biased the previous sample of data was, or the next sample is. Only if the hypothesis is disproven do biases in the sample come under question. For generating theory these biases are treated as conditions changing the relationship, which should be woven into the analysis as such. Thus, random sampling is not necessary for theoretical sampling, either to discover the relationship or check out its existence in other

groups. . . . However, when the sociologist wishes also to describe the magnitude of relationship within a particular group, random sampling, or a highly systematic observation procedure done over a specified time is necessary. For example, after we discovered the positive relationship between the attention that nurses gave dying patients and the nurses' perceptions of a patient's social loss, we continually found this relationship throughout our research and were quick to note conditions altering its direction. But we could never state the precise magnitude of this relationship on, say, cancer wards, since our sampling was theoretical.

Another important difference between theoretical and statistical sampling is that the sociologist must learn when to stop using the former. Learning this skill takes time, analysis and flexibility, since making the theoretically sensitive judgment about saturation is never precise. The researcher's judgment becomes confidently clear only toward the close of his joint collection and analysis, when considerable saturation of categories in many groups to the limits of his data has occurred, so that his theory is approaching stable integration and dense development of properties.

By contrast, in statistical sampling the sociologist must continue with data collection no matter how much saturation he perceives. In his case, the notion of saturation is irrelevant to the study. Even though he becomes aware of what his findings will be, and knows he is collecting the same thing over and over to the point of boredom, he must continue because the rules of accurate evidence require the fullest coverage to achieve the most accurate count. If the researcher wishes to diverge from his preplanned research design because of conceptual realizations and implicit analyses, he must hold his wish in

> abeyance or laboriously integrate his new approach into the research design, to allow a new preplanned attack on the total problem. He must not deviate from this new design either; eventually it leads him back into the same "bind."

The reader should now have a working understanding of the roots of the sampling strategy employed in this study. It should properly be called verstehende sociological sampling because it is based upon the essential principle of verstehende sociology, which is to examine and try to understand the world of informants and hence to know it as they themselves do. The present research is directed toward obtaining some initial or baseline data on social impact. It is therefore necessarily directed toward learning how residents in the study area are individually and collectively experiencing, defining, finding meaning in, and acting toward industrial interventions and other coal-related changes in their social world. The researchers are seeking to "know" coal-related social impact as informants themselves are coming to know it. This research method is most suited to enabling the researcher to get close enough to his subjects and their perceptions, thoughts, feelings, and actions in their natural settings to understand their membership and participation in society as they themselves do.

Having chosen their method, the researchers proceeded to sample people in the study area sociologically (explained below). There were some exceptions to be sure. For example, it was necessary to purposely and deliberately seek out certain social categories which had only one or a few representatives in the region (e.g., county public health nurse, land developers, county sheriff, and so on) because of the obvious need to make sure that their observations of coal-related developments were not missed. In general, the fieldwork approach was to use a procedure designed to obtain data which would reveal what informants considered to be a representative view of themselves and each other in their everyday activities and situations.

While following informants' suggestions of persons to contact in order to obtain viewpoints, experiences, and the like which so cover the entire spectrum of such matters that they adequately represent what the researcher is seeking to identify, describe, and analyze, the researcher is obliged to continually search for evidence that the informants' suggestions are based upon misinformation, faulty perceptions, and so on. The idea is to go after

negative cases and unexpected results, not to prove the informants wrong but (in this study) to quickly and efficiently get to the limits of their knowledge of the types, life-styles, needs, hopes, fears, commitments, and so forth of people who live in their vicinity or elsewhere in the study area. As soon as the researcher is able to consistently and accurately predict how informants (who were selected with the help of other informants) are going to respond to certain of his basic research questions (on how they define their place in the coal development situation, for example), he moves on to other types of questions and to other types of informants. When the researcher has exhausted his and his informants' abilities to identify other kinds of informants and other sorts of questions of interest to him and therefore of relevance to his research objectives, it is time to terminate this phase of the study and begin putting findings together. Note that in sampling sociologically the researcher does not rely upon his judgment alone, or even principally. Rather, he relies upon the social knowledge of people in the study area to help him to "saturate" the empirical categories pertaining to sampling. In their discussion of theoretical saturation, Glaser and Strauss (1967, pp. 61-62) give sound direction for deciding when it is time to stop sampling kinds or categories of behavior.

> As we have said, The sociologist trying to discover theory cannot state at the outset of his research how many groups he will sample during the entire study; he can only count up the groups at the end. Since data for various categories are usually collected from a single group--although data from a given group may be collected for only one category--the sociologist usually is engaged in collecting data from older groups, or returning to them, while simultaneously seeking new groups. Thus he continually is dealing with a multiplicity of groups, and a multiplicity of situations within each; while absorbed with generating theory he would find it hard to count all these groups. (This situation contrasts with that of the researcher whose study involves verification or description, in which people are distributed throughout various categories, and he, therefore, must state the number of groups that will be sampled, according to rules of evidence governing the collection of reliable data.)
>
> Even during research focused on theory, however, the sociologist must continually judge how many groups he should sample for each

> theoretical point. The criterion for judging when to stop sampling the different groups pertinent to a category is the category's <u>theoretical saturation</u>. <u>Saturation</u> means that no additional data are being found whereby the sociologist can develop properties of the category. As he sees similar instances over and over again, the researcher becomes empirically confident that a category is saturated. He goes out of his way to look for groups that stretch diversity of data as far as possible, just to make certain that saturation is based on the widest possible range of data on the category.
>
> One reaches theoretical saturation by joint collection and analysis of data. . . . When one category is saturated, nothing remains but to go on to new groups for data on other categories, and attempt to saturate these new categories also. When saturation occurs, the analyst will usually find that some gap in this theory, especially in his major categories, is almost, if not completely filled. In trying to reach saturation he maximizes differences in his groups in order to maximize the varieties of data bearing on a category, and thereby develops as many diverse properties of the category as possible. The criteria for determining saturation, then, are a combination of the empirical limits of the data, the integration and density of the theory, and the analyst's theoretical sensitivity.

<u>Ongoing Validation of Data</u>

The researchers continually checked information obtained from given persons with what was learned from other individuals in order to clarify and substantiate the information per se and their understanding of it. They sometimes worked as a team in gathering data and at other times alone but always in such a way that it was necessary for each one to continually check his information and findings with those of others on the staff. Moreover, earlier drafts of this report were reviewed with a cross-section of the study area's residents as part of the checking procedure.

In addition to continually validating data using both informants and each other, the researchers relied on a multiplicity of research techniques to systematically cross-check descriptions and analyses. They utilized open-ended interviews, a wide range of personal observations, small and large group discussions, and analyses of such secondary sources of information as the 1970 population census of Montana. Various categories of informants gave information which was compared and weighed against what was found out from various other categories of informants. The team strove for assurance and several kinds of reassurance that the data were valid or, in Glaser and Strauss's terms, that "theoretical saturation" had been achieved. In Denzin's term, the method of "triangulation" was used.

> Sociology's empirical reality is a reality of competing definitions, attitudes, and personal values. As such, it is a social object in the symbolic environment of the scientist. Any attempt to approximate knowledge of this object must acknowledge this fact. The act of doing research is an act of symbolic interaction. Each sociological method and, in fact, each sociologist generates different lines of action toward this object. Thus, complete agreement between methods and their users can never be expected. But there are rules of method that govern the sociologist's conduct. His actions--from the use of methods, to the personal values that shape the sociological act--must be made public.
>
> Triangulation, or the use of multiple methods, is a plan of action that will raise sociologists above the personalistic biases that stem from single methodologies. By combining methods and investigators in the same study, observers can partially overcome the deficiencies that flow from one investigator and/or one method. Sociology as a science is based on the observations generated from its theories, but until sociologists treat the act of generating observations as an act of symbolic interaction, the links between observations and theories will remain incomplete. In this respect triangulation of method, investigator, theory, and data remains the soundest strategy of theory construction. (Denzin 1970, p. 300)

Documentation

Documentation has to do with how the investigator knows something is so and with demonstrating this to the reader's satisfaction. In scholarly and scientific works, each discipline has its conventions for documenting statements in such a way that the reader can check them out to determine their authenticity and credibility or perhaps to obtain more complete information from an original source.

In reports on survey research on human behavior, documentation is built into the tabular presentations of data. Here the investigator shows how many respondents of given categories replied in specified ways to particular questions. It is understood by all concerned that in this kind of research much effort is devoted to prestructuring the information-gathering activity, usually in the form of a questionnaire which is either self-administered or administered by an interviewer. It is further understood that every effort is made to neutralize or at least standardize the influence of the person administering the questionnaire upon the respondent, so as the control for "interviewer effect" and consequently to be reasonably certain that the responses will be as much as possible merely a function of the stimuli provided by the written questions. Following the rules for documentation of data generated by statistical sampling, both the investigator and the qualified reader of his report understand, for example, that when numbers in the tables are a certain size or larger, they indicate that a significant part of the population which is being reported said this or did that.

This kind of attention to the number of respondents and to the distribution of their responses is understandable when examining the documentation in reports on survey or other nomothetic research. However, it has no place in ethnographic research or in any other social research which calls for the investigator to maximize, rather than to minimize, interviewer effect with a view to developing relationships with informants which have the effect of facilitating the generation of desired data (Gold 1954). In this kind of research, the process of obtaining data is the key factor in documenting, not the number of interviews conducted or responses obtained. The process involves finding ways of demonstrating to the informant that the interviewer is a qualified, congenial, and trustworthy recipient of information on things in the informant's life about which the respondent cares and takes significantly into account. The

fieldworker does more than just question the informant; he sometimes challenges the informant's responses, declares his inability to see how a given reply is so different from or stereotypical of other individuals in his social category, discusses the informant's situation with him, and in other ways tries to develop a relationship which has the effect of helping the person being interviewed to play his role fully and well. In social psychological terms, the ethnographic fieldworker seeks personally and directly to help the informant to maximize self-expression at minimal self-risk (Gold 1954).

If the informant happens to be both knowledgeable and articulate, the amount of desired information obtained in a single interview, or perhaps in a series of interviews with that person, can be large. A few such informants can quickly and expertly reveal to the fieldworker much about the organization and operation of their community, particularly if it is a small one such as those found in the study area.

All this is meant to point out that the ethnographer documents his data not by reporting how many people responded in certain ways to standardized questions asked rather mechanically and unobtrusively but by describing how he developed relationships with informants so as to help them share with him their knowledge of whatever it is he seeks to learn.[5] Accordingly, it is standard practice in the final reports of ethnographic studies to include chapters, sections of chapters, or appendixes which describe in detail how the researcher entered the field, made contact with potential informants, developed (and in some instances failed to develop) relationships with interviewees, used (or at times failed to use) the relationship to generate data, checked the information, and (in studies of literate societies) even got informants to criticize drafts of his reports to help him to represent their social world as they see and experience it.

Observer Bias

As a safeguard against unintentionally biasing the data, ethnographic researchers often arrange to do reality checking of their findings in addition to conducting ongoing validation of the data. The latter process involves regularly reviewing with informants the emerging data and the researchers' understanding of what the findings mean to the people being studied. Reality checking requires that informants representing the diverse groups and opinions of interest to the research check what the researchers have put

together from the data gathered and then affirm that what has been said does in fact accurately represent the situation as they see it. For example, the research team spent an average of two to three hours going over earlier versions of this report with each of a dozen informants, most of whom had already been interviewed and all of whom were regarded as representative of the major social groupings and points of view being studied. Not one of these dozen informants found anything about the report more than minimally objectionable, and all their objections and other responses have already been taken into account. None was troubled by the reporting style of speaking for the area's residents, although in the present report a special effort has been made to make it explicit when the views of informants are being presented and when the researchers themselves are commenting about the data.

Ethnographers have an obligation to be accountable first and foremost to the people whose social impacts they are studying; only secondarily are they accountable to critics, colleagues, or to any other group. In short, reality checking has to be done primarily with the people inside the world being studied, not with those outside the social world which the researchers are trying to faithfully describe. Thus, the present report attempts to paraphrase, summarize, and occasionally quote what informants said about themselves, their fellows, and others who have recently entered their world; the researchers have confined their comments to separate, short discussion sections which are marked as such.[6]

Content Footnotes for Appendix H1

[1]See also Theodore Abel, "The Operation Called Verstehen," American Journal of Sociology, 54, no. 3 (November 1948): 211-18.

[2]It should be noted that a small number of construction workers have contributed inordinately to the workers' reputation as "barroom trouble-makers."

[3]Ethnomethods are systematic efforts to account for the behavior of people being studied as they themselves do while they are in process of trying to fit their actions together so as to make (or avoid making) society with each other.

[4]A self-fulfilling prophecy is a prediction which has a way of actually happening because the person making the prediction wittingly and/or unwittingly acts in ways which help to make his prediction (e.g., a definition of a situation) come true.

[5]Two good examples of such description are: Bronislaw Malinowski, Argonauts of the Western Pacific (New York: E.P. Dutton & Co., 1950); and William Foote Whyte, Street Corner Society, 2nd ed. (Chicago: University of Chicago Press, 1955).

[6]Readers sometimes wonder if the researchers--wittingly or unwittingly--have put words into informants' mouths or have chosen informants whose views are known to coincide with their own to document their findings. These same readers often unquestioningly accept statistical reports, failing to realize that a judicious selection of questionnaire items or choice of statistics can also very readily present a distorted picture of an actual situation. There are potential strengths and weaknesses in both research methods.

H2 Survey Methodology

The questionnaire.

Items included in the questionnaire came from a number of sources. Many were suggested by earlier, related fieldwork carried out by staff of the University of Montana and Montana State University. Some resulted from conversations with residents of the area who are concerned about the consequences of energy development. Many items were included because they represented specific points of interest to the investigators or because they sought information which would be helpful to decision makers.

A preliminary draft of the questionnaire was pretested in the field to assess its adequacy and to identify items of dubious worth and vague or poorly worded items. Respondent comments and suggestions from interested parties resulted in considerable modification of the original instrument.

Interviewing commenced in the last week of June, 1974, and terminated in the opening days of August 1974. Analysis of the data by computer was initiated at that time and completed by September 1st. The survey results reflect opinions and impressions from that time period. It is possible that if the survey were to be repeated today, the specific numbers and percentages of people answering a given question in a particular way would shift. Any number of events may have occurred which could alter the response to questionnaire items. As such, it is important to emphasize that a particular percentage attached to a response category may not be as crucial as the trend of opinion it may represent.

Sample selection.

The survey was based on a stratified random sample of three percent (179) of the approximately 6,000 residents in the study area. According to the 1970 census, about fifty-eight percent of the population of Rosebud County was aged twenty years or over; hence the three percent sample of the estimated total population represented slightly over five percent of the adult population in the study area.

The sample was stratified to include five categories of persons:

1) Residents of Forsyth, Hathaway, and Rosebud, in the northern part of the study area.

2) Residents of Colstrip.

3) Landowners and ranch hands living south of the Yellowstone River and north of the Northern Cheyenne Reservation, in Rosebud County.

4) Residents of the Ashland area.

5) Residents of the area south of the Northern Cheyenne Reservation, in Rosebud County.

Acceptable respondents were defined as persons eighteen years old or older, residents in the study area, and mentally and physically capable of participating in the survey. As it turned out, only one person in the sample was under twenty years of age. Two main groups were encountered which were unacceptable as respondents. One group comprised those construction workers who maintained homes elsewhere, primarily in Billings, and who slept in the Burtco barracks four nights a week. These men were eliminated before the sample was drawn. Men who belonged in the same category but who were sleeping in campers or trailers were replaced when it was discovered that they were drawn as part of the sample.

The second group defined as unacceptable were those elderly persons, mainly in Forsyth, who because of advanced age or ill health were unable to participate in the survey interview. In many instances they refused to participate. If such individuals inadvertently appeared in the sample, they were replaced.

The base population of the study area, from which the sample was drawn, was carefully compiled to ensure inclusion of all acceptable respondents. The latest official U.S. census data were for 1970 and were therefore seriously outdated by the summer of 1974. Fortunately, several sources of current data were at hand and were utilized to bring population lists up to date. For the northern part of the study area (Forsyth, Hathaway, and Rosebud) the electricity users list of the Montana-Dakota Utilities

Company was available. A random check verified the list's completeness and accuracy.

In Colstrip, Burtco's rental lists identified occupants of the construction trailer sites, and Western Energy's rental lists identified occupants of permanent trailer sites, houses, and apartments. Fieldworkers identified occupants of two trailer parks near Colstrip. The Bureau of Land Management provided its list of landowners in Rosebud County; this was the basic list used to identify residents in the study area who lived outside of Forsyth, Hathaway, Rosebud, and Colstrip. To ensure that all small landowners were included, the BLM list was checked against the Rosebud-Treasure Wildlife Association Land Ownership Map. The revised list was reviewed by several local residents to exclude those landowners who resided outside the study area and who had no one living on their Rosebud County land.

The base population list for the Ashland-Birney portion of the study area was generated with the aid of researchers from Montana State University by checking the BLM list against telephone and post office lists. Local residents reviewed the results for completeness. We are satisfied that no significant error occurred in the determination of the base population from which the study sample was drawn.

A table of random numbers was used to select the sample. For the populations in each of the five categories described above, random numbers were applied, and every kth item (address) was selected to provide three percent of the items in that category. The completed sample for the study area included 179 names and addresses.

Interviews.

The survey was conducted through personal interviews by trained field interviewers from the University of Montana and Montana State University. Senior staff members from the Institute for Social Science Research of the University of Montana supervised the fieldwork and carried out some of the interviews.

In order to facilitate the interviewing process, appointments were made in advance in all except a small number of cases, with people who did not have telephones. Despite the length of the questionnaire, relatively few

persons refused to be interviewed. In these cases, replacements were made in order to keep the size and character of the sample intact.

Interviewing time varied considerably, from about an hour and a half when respondents answered promptly and concisely, to three hours or more when they proved to be unusually loquacious. Average time was around two hours.

Completed questionnaires were returned to the field station in Colstrip, where they were spot checked for completeness, legibility, etc. by one of the staff supervisors. Interviewers met with supervisory staff periodically to discuss progress of the work and any problems encountered in the field.

Coding and data analysis.

For ease and simplicity of data transferral, the questionnaire contained a coding column arranged so that each item could be coded directly on the questionnaire, eliminating the need for a separate coding sheet. Computer data cards were punched from the questionnaires; the DECsystem-10 computer at the University of Montana was used for all computations.

In order to exploit fully the substantial body of data and large number of variables provided by the survey, a comprehensive program, CROSTABS, was selected. In addition to frequency distribution and percentages, this program computes a number of statistics for cross-tabulation tables. These include gamma; lambda; Goodman and Kruskal's tau; chi-square with Yates correction; Phi; Pearson's contingency coefficient (C); Kruskal-Wallis one-way analysis of variance, or the Mann-Whitney u-statistic, depending on the number of columns in the table; Kendall's Tau-B; Kolmogoroz-Smirnov One Sample Test; and Willcoxon Matched-Pairs Signed Ranks test. In many instances all of these measures are not immediately useful for purposes of this report; however, they are readily available should a more sophisticated analysis of the survey data be desired. Tables presented herein contain, in addition to numerical and percentage distribution, chi-square, degrees of freedom, and level of probability.

H3 Energy Planning Division Public Opinion Questionnaire

Cover letter.

Dear Fellow Montanan,

Are Montanans concerned that power companies plan to build electrical generating plants in the State? What do Montanans think about strip mining? What benefits and disadvantages do Montanans see associated with coal development and electric utility construction?

These are just three of many questions the State of Montana, Energy Planning Division wishes to answer by going to you, the Montana citizen, to get your opinion. Your name was selected at random from voter registrations, lists of taxpayers, and telephone books to participate in this state-wide opinion poll. The Energy Planning Division is now in the process of studying proposals concerning the use of Montana coal and the construction of electric utilities in the State. To make the best possible recommendations to the greatest benefit of all Montanans, the Energy Planning Division wants to hear your opinions on these issues.

Enclosed is a questionnaire to gather your opinions. There are no right or wrong answers. It's your opinion that counts. Instructions for filling it out and some example questions are located on the back side of this letter and again in the questionnaire. Please answer all of the questions, place the questionnaire in the enclosed return envelope and send it to the Energy Planning Division. The questionnaire will take less than 30 minutes of your time to complete and we are sure you'll find it interesting. If you have any questions concerning filling out the questionnaire call the Citizen's Advocate Office's toll free number (1-800-332-2272). Their office will then contact the Energy Planning Division. Do not sign the questionnaire. All questionnaires are confidential and anonymous.

Thank you for your time, consideration and concern for Montana's future.

Sincerely,

ALBERT C. TSAO, ADMINISTRATOR
ENERGY PLANNING DIVISION

John Fitzpatrick, Sociologist
Energy Planning Division

Follow-up letter.

Dear Fellow Montanan:

In the past few days, the Energy Planning Division mailed you a questionnaire asking your opinions on strip mining and the construction of electric power plants and high voltage electric transmission lines within Montana. If you have not already filled out that questionnaire and returned it, please do so now.

Montana energy development has emerged as an important issue for those in state government as well as for those people living in communities where energy development is currently taking place or may do so in the future. It is critical that state policy makers and planners hear from you, the Montana citizen, so that the best possible recommendations and decisions can be made to the greatest benefit of all Montanans.

In the event the first questionnaire was misplaced, a second questionnaire is enclosed. Please fill it out, place it in the return envelope and mail the questionnaire to the Energy Planning Division. Do not fill in a second questionnaire if you have already completed one.

Thank you for your time, consideration, and concern for Montana's future.

Sincerely,

ALBERT C. TSAO, ADMINISTRATOR
ENERGY PLANNING DIVISION, DNRC

JOHN S. FITZPATRICK, SOCIOLOGIST
ENERGY PLANNING DIVISION, DNRC

Instructions and Example Questions.

These are three general types of questions in this public opinion survey.

In Section I a statement is followed by response categories ranging from strongly agree to strongly disagree. Circle the response that is closest to your opinion of the statement.

EXAMPLE 1:

The beef raised in Montana is very tasteful.

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

If you strongly agree with the above statement then you would circle strongly agree as the example illustrates. If your opinion of the statement fits some other response, then you would circle the most appropriate response.

In Section 2 you are asked to rank items on a scale from one to five. In the blank space provided write a number that corresponds with your opinion of the item.

EXAMPLE 2:

Less Tasteful				More Tasteful
1	2	3	4	5

_5_ A. T-Bone Steak
_2_ B. Beef Liver
___ C. Hamburger

If you think T-Bone Steak is very tasteful, then write a high number in the space provided as the example question indicates. If you dislike the taste of liver put a correspondingly low number in the appropriate blank space. Rank each of the items on the list. A number from the scale may be used as often as you wish.

The third type of question found in sections two and three asks you to put a check mark in the appropriate space or fill in a blank space with a few words.

EXAMPLE 3:

I prefer the taste of beef to the taste of pork.

(X) Yes
( ) No
( ) Undecided

If Yes: In your opinion where is the best tasting beef raised? MONTANA

Questionnaires.

MONTANA
ENERGY PLANNING DIVISION
PUBLIC OPINION SURVEY
(Form A)

Montana Attitudes of State Energy Development

Section 1: Instructions: Read each statement and circle the response that is closest to your opinion of the statement.

1. In order to live in Montana, I am willing to pass by opportunities for potentially higher income that might be earned elsewhere. (circle one)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

2. I would prefer to live in an area without the presence of strip mining operations. (circle one)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

3. I prefer to live in Montana as it currently is rather than risk possibly damaging the state by further industrialization. (circle one)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

4. I am very interested in the issues of coal development and the construction of electric utilities in Montana. (circle one)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

5. I favor the construction of coal-burning electric generating power plants in Montana. (circle one)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

6. I would have <u>no</u> objection to living in an area where coal-burning electric power plants are located. (circle one)

   Strongly Agree Agree Neutral Disagree Strongly Disagree

7. I consider myself well informed about the issues of coal development and electric utility construction in Montana. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

8. Strip mining Montana's coal is acceptable if strong environmental safeguards are provided to protect the land, air, water and lifestyle of Montana residents. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

9. Coal-burning electric power plants should be built in the areas where the electric power will be consumed. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

10. I favor the construction of high voltage electric transmission lines within Montana. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

11. The industrial development of Montana should be encouraged. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

12. <u>Not</u> much information concerning coal development and the construction of electric utilities in Montana is being made available to the general public. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

13. High voltage electric transmission lines should be constructed in areas where power lines currently exist. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

14. Power companies should pay an annual fee to property owners whose lands are crossed by electric transmission lines. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

15. Strip mining should not be prohibited in Montana. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

16. If Montana coal is needed for the generation of electricity, the coal should be transported to the areas where the electricity is needed. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

17. The need for electricity will require injuring the beauty of an area by constructing and operating electric utilities. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

18. I oppose the construction of coal-burning electric power plants in Montana when the electricity is largely shipping to other states. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

19. Construction of coal-burning electric power plants is acceptable if strong environmental safeguards are provided to protect the land, air, water, and lifestyle of Montana residents. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

20. If new industry is to be built in Montana, it should be directed to areas of the state that are already industrialized. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

21. I would prefer to live in an area without the presence of high voltage electric transmission lines. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

22. If a power company wishes to construct a coal-burning power plant, it should be required to <u>pre-pay</u> the additional cost of providing schools, sewers, roads, recreational facilities, etc. in the area. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

23. Montana needs the electricity from the proposed coal-burning electric generating plants to be located at Colstrip, Montana. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

24. I would have no objection to the presence of a high voltage electric transmission line on my property. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

25. The taxes generated by the construction and operation of power plants and electric transmission lines will result in a lessening of the tax load paid by other Montana citizens. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

26. One way of providing future generations of Montanans with job opportunities is to promote the industrialization of the state. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

27. The consumers of electricity should bear the social and environmental costs associated with the construction and operation of coal-burning electric power plants. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

28. Most people in Montana are well informed about the issues of coal development and electric utility construction. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

29. By and large, the information the Montana public receives concerning the issues of coal development and electric utility construction within the state is accurate. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

30. High voltage electric transmission lines should be built in relatively uninhabited areas of the state. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

31. I favor the unrestricted strip mining of Montana coal. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

32. If coal-burning electric power plants are to be built in Montana, it is best to locate the plants in areas already used for industrial purposes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

33. High voltage electric transmission lines should only be constructed if they are designed to specifically serve Montana residents. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

34. If a power company wishes to construct a coal-burning electric power plant, it should not be required to pay the additional cost of providing schools, sewers, roads, recreational facilities, etc. in the area. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

35. Encouraging the construction and operation of power plants and electric transmission lines would be a wise step toward providing future generations of Montanans with job opportunities. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

36. The mining companies cannot be trusted to provide environmental safeguards unless compelled to do so by law. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

37. Provided high voltage electric transmission lines are not located on my property, I have no objection to having them built elsewhere. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

38. Coal-burning electric power plants and agriculture can co-exist side-by-side in the same area. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

39. How many news articles, broadcasts, documentaries, or programs have you seen, heard, or read in the past six months dealing with Montana coal development and electric utility construction? (circle one)

None   1-5   6-10   11-15   16 or more

Section 2: Instructions: There are two types of questions in this section. One type of question asks you to rank a list of items on scales from 1 to 5. The other type of question asks you to place a check mark in a blank space or write a few words. With the ranking scales a number may be used as often as you wish.

40. Rank the items below in terms of how much (not accuracy) information you believe these organizations provide the general public concerning the issues of coal development and electric utility construction. (Put a number in each blank space).

Less Information				More Information
1	2	3	4	5

____a. Federal Government Agencies
____b. State Government Agencies
____c. Power Companies
____d. Environmental Groups
____e. Labor Unions
____f. Citizens Groups
____g. Mining Companies
____h. Local Government Agencies
____i. The News Media (excluding news releases from other organizations)
____j. Other (specify)________________________

41. Again, using the 5 point scale rank the organizations based on your opinion of the accuracy of the information they make available to the public. (Put a number in each blank space.)

Less Accurate				More Accurate
1	2	3	4	5

____a. Citizens Groups
____b. Labor Unions
____c. Federal Government Agencies
____d. Local Government Agencies
____e. The News Media (excluding news releases from other organizations)
____f. Mining Companies
____g. Power Companies
____h. Environmental Groups
____i. State Government Agencies
____j. Other (specify)____________________

42. Is there any type of organization which is providing information concerning coal development and electric utility construction in Montana that you distrust? (check one)

( ) Yes ( ) No ( ) Undecided

42A. If yes: What type of organization do you distrust?____________________
Why?____________________
____

43. If you were asked to select a location within Montana where the construction and operation of a coal-burning electric power plant would do the most good and least harm, where would you locate such a plant? (Name a town, city, or county.)

1st Choice____________________
2nd Choice____________________

44. Below is a list of possible sources of information. Using the 5 point scale rank these sources according to how frequently you use them to

receive information concerning coal development and electric utility construction in Montana. (Put a number in each blank space.)

Seldom				Often
1	2	3	4	5

____a. Conversation with other people
____b. Magazines
____c. Radio
____d. Public Meetings
____e. Television
____f. Newspapers
____g. Other (specify)________________________________

45. National energy needs can best be met by: (check one)

( ) increasing strip mining in Montana
( ) increasing the number of electric generating plants in Montana
( ) individuals and families conserving energy
( ) industry and commercial institutions conserving energy
( ) developing alternative sources of energy such as the sun and wind
( ) other (specify) ________________________________

46. In general, and as a rule, who should pay the local economic costs of industrialization of coal resources such as expansion of law enforcement, public health, educational services, etc? (check one)

( ) industry
( ) local government
( ) state government
( ) federal government
( ) the people who directly benefit from the energy produced
( ) all of the above
( ) none of the above (indicate who should pay in this case)__________

47. Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits

of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much? (check one)

( ) There should be no further development; what we have under way is enough.
( ) Further development should be confined to mining and exporting coal.
( ) Further development should be confined to mining and mine-mouth coal burning electric power plants.
( ) Further development should not be restricted, but should be a direct response to what the rest of the nation says it wants.

CONFIDENTIAL

Section 3: Instructions: In this section we need some personal information about yourself. Place a check mark or write the appropriate response in the space provided. Please remember that this questionnaire is confidential and anonymous.

48. Sex: (Check One) ( ) Male ( ) Female

49. Age: (Check One)

( ) 15-24 ( ) 55-64
( ) 25-34 ( ) 65-74
( ) 35-44 ( ) 75 +
( ) 45-54

50. Education: (Check One)

( ) Elementary school (8 years or less)
( ) Some High School
( ) High School Graduate
( ) Some College (Include vocational-technical schools)
( ) College Graduate
( ) Graduate or professional training

51. Occupation (be specific):

Self ____

Spouse (if applicable) ______________________________

52. Are you a native-born Montanan? (Check One) ( ) Yes ( ) No

53. Length of residence in Montana: (Check One)

( ) Less than one year
( ) 1-5 years
( ) 6-10 years
( ) 11-15 years
( ) 16-25 years
( ) more than 25 years

54. Race and Ethnicity: (Check One)

( ) Caucasion
( ) American Indian
( ) Other (Specify) ______________________________

55. Political Affiliation: (Check One)

( ) Democrat
( ) Republican
( ) Independent
( ) Other (Specify) ______________________________

56. Estimated annual family income before taxes (Check One).

( ) Less than $2,999
( ) $3,000 - $4,999
( ) $5,000 - $6,999
( ) $7,000 - $9,999
( ) $10,000 - $14,999
( ) $15,000 - $24,999
( ) $25,000 +

57. County of Residence? ______________________________

58. Place of residence by size: (Check One)

( ) City greater than 50,000 population
( ) City population from 10,000 - 49,999
( ) City population from 2,500 - 9,999
( ) City or town less than 2,499 population
( ) Rural - farm or ranch
( ) Suburban lot
( ) Other (Specify) ______________________________

59. Is there a right-of-way for any of the following facilities located on your property, or have you sold right-of-way for any of these facilities? (Check all that apply)

( ) Railroad
( ) Highway
( ) Pipeline
( ) Power line

( ) Yes

( ) No

60. If you wish to receive a copy of the opinion poll results please write your name and address in the space provided or send a post card to the Energy Planning Division with your request.

61. Do you have any additional comments concerning the issues of coal development and electric utility construction in Montana? In the space below or on the back side of the questionnaire, please add any remarks you may wish to make.

MONTANA
ENERGY PLANNING DIVISION
PUBLIC OPINION SURVEY
(Form B)

Montana Attitudes of State Energy Development

Section 1: Instructions: Read each statement and circle the response that is closest to your opinion of the statement.

1. In order to live in Montana, I am willing to pass by opportunities for potentially higher income that might be earned elsewhere. (circle one)

   Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

2. I would prefer to live in an area without the presence of strip mining operations. (circle one)

   Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

3. I prefer to live in Montana as it currently is rather than risk possibly damaging the state by further industrialization. (circle one)

   Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

4. I am very interested in the issues of coal development and the construction of electric utilities in Montana. (circle one)

   Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

5. I would have <u>no</u> objection to living in an area where coal-burning electric power plants <u>are</u> located. (circle one)

   Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

6. I consider myself well informed about the issues of coal development and electric utility construction in Montana. (circle one)

   Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

7. I favor the construction of high voltage electric transmission lines within Montana. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

8. The industrial development of Montana should be encouraged. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

9. Not much information concerning coal development and the construction of electric utilities in Montana is being made available to the general public. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

10. I oppose the construction of coal-burning electric power plants in Montana where the electricity is largely shipped to other states. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

11. If new industry is to be built in Montana, it should be directed to areas of the state that are already industrialized. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

12. I would prefer to live in an area without the presence of high voltage electric transmission lines. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

13. The taxes generated by the construction and operation of power plants and electric transmission lines will result in a lessening of the tax load paid by other Montana citizens. (circle one)

Strongly Agree Agree Neutral Disagree Strongly Disagree

14. Encouraging the construction and operation of power plants and electric transmission lines would be a wise step toward providing future generations of Montanans with job opportunities. (circle one)

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

15. How many news articles, broadcasts, documentaries, or programs have you seen, heard, or read in the past six months dealing with Montana coal development and electric utility construction? (circle one)

None   1-5   6-10   11-15   16 or more

Section 2: Instructions: There are two types of questions in this section. One type of question asks you to rank a list of items on scales from 1 to 5. The other type of question asks you to place a check mark in a blank space or write a few words. With the ranking scales a number may be used as often as you wish.

16. Rank the items below in terms of how much (not accuracy) information you believe these organizations provide the general public concerning the issues of coal development and electric utility construction. (Put a number in each blank space.)

Less Information ————————————————— More Information
1   2   3   4   5

____a. Federal Government Agencies
____b. State Government Agencies
____c. Power Companies
____d. Environmental Groups
____e. Labor Unions
____f. Citizens Groups
____g. Mining Companies
____h. Local Government Agencies
____i. The News Media (excluding news releases from other organizations)
____j. Other (specify) ______________________

17. Again, using the 5-point scale, rank the organizations based on your opinion of the <u>accuracy</u> of the information they make available to the public. (Put a number in each blank space.)

Less Accurate				More Accurate
1	2	3	4	5

____a. Citizens Groups
____b. Labor Unions
____c. Federal Government Agencies
____d. Local Government Agencies
____e. The News Media (excluding news releases from other organizations)
____f. Mining Companies
____g. Power Companies
____h. Environmental Groups
____i. State Government Agencies
____j. Other (specify)______________________________

18. Is there any type of organization which is providing information concerning coal development and electric utility construction in Montana that you distrust? (check one)

( ) Yes ( ) No ( ) Undecided

18A. If yes: What type of organization do you distrust? ____________________
Why? ____
____

19. If you were asked to select a location within Montana where the construction and operation of a coal-burning electric power plant would do the most good and least harm, where would you locate such a plant? (Name a town, city or county.)

1st Choice ______________________________
2nd Choice ______________________________

20. Below is a list of possible sources of information. Using the 5-point scale, rank these sources according to how frequently you use them to receive

information concerning coal development and electric utility construction in Montana. (Put a number in each blank space.)

Seldom				Often
1	2	3	4	5

____a. Conversation with other people
____b. Magazines
____c. Radio
____d. Public Meetings
____e. Television
____f. Newspapers
____g. Other (specify) ______________________________

21. Below is a list of potentially <u>adverse</u> features which might be expected to accompany the construction and operation of strip mines, coal-burning electric power plants, and high voltage electric transmission lines. Rank each of the items based on your opinion as to how adverse such an event would be should it occur. (Put a number in each blank space)

Less adverse				More adverse
1	2	3	4	5

____a. A potential increase in crime and other forms of deviant behavior.
____b. A potential population increase.
____c. A potential increase in the pollution of land, air, and water.
____d. A potential for cost of living increases.
____e. A potential for the loss of water from agricultural to industrial use.
____f. A potential increase in health hazards to man, animals, and plants.
____g. A potential loss of or damage to existing recreational facilities.
____h. A potential breakdown of friendship and family ties.
____i. A potential for increases in taxation to owners of residential, commercial, and agricultural property.
____j. A potential loss of agricultural land to industrial use.
____k. A potential overcrowding of educational facilities.
____l. A potential for damage to existing transportation facilities.
____m. A potential overcrowding of housing facilities.
____n. A potential for damage to the established business community.
____o. Other (specify) ______________________________

22. Below is a list of potentially beneficial features which might be expected to accompany the construction and operation of strip mines, coal-burning electric power plants, and high voltage electric transmission lines. Rank each of the items based on your opinion as to how beneficial such an event would be should it occur. (Put a number in each blank space)

Less beneficial				More beneficial
1	2	3	4	5

____a. A potential population increase.
____b. A potential improvement in educational facilities.
____c. A potential improvement in recreational facilities.
____d. A potential opportunity to meet new people.
____e. A potential for improvement in shopping and professional services.
____f. A potential increase in job opportunities.
____g. A potential increase in tax revenues.
____h. A potential for improvement in social and cultural facilities.
____i. A potential improvement in housing facilities.
____j. A potential improvement in transportation facilities.
____k. A potential improvement in opportunities for capital investment.
____l. A potential contribution to industrial growth and energy self-sufficiency for the United States.
____m. A potential to attract more industry to the area.
____n. A potential for broadening the economic base of Montana.
____o. Other (specify) ______________________________

23. On the whole, do the potential beneficial features of coal development and the construction and operation of electric utilities equal the potential adverse features?

( ) Yes ( ) No ( ) Undecided

IF NO:

23a. Do the potential beneficial features outweigh the potential adverse features?
( ) Yes ( ) No

IF YES:
23c. How much do the potential beneficial features outweigh the potential adverse features?
( ) Very much
( ) Quite a bit
( ) A little
( ) Undecided

23b. Do the potential adverse features outweigh the potential beneficial features?
( ) Yes ( ) No

IF YES:
23d. How much do the potential adverse features outweigh the potential beneficial features?
( ) Very much
( ) Quite a bit
( ) A little
( ) Undecided

24. Again, using the 5 point scale, rank the following list of industries according to your opinion as to their desirability to have located or expanded in Montana. (Put a number in each blank space.)

Less Desirable				More Desirable
1	2	3	4	5

____a. Underground mining
____b. Recreation and tourism
____c. Light industry such as textiles and clothing, printing and publishing, etc.
____d. Strip mining
____e. Food processing such as slaughterhouses, flour mills, canneries, etc.
____f. Heavy industry such as smelting, sawmills, oil refining, metal fabricating, etc.
____g. Generation and transmission of electricity
____h. Wholesale and retail trade
____i. Agriculture
____j. Transportation
____k. Other (specify) ______________________________

25. Rank the following list of potential industrial facilities according to your opinion of their desirability within Montana. (Put a number in each blank space.)

Less Desirable ——— More Desirable
1 2 3 4 5

____a. High voltage electric transmission lines.
____b. Coal-fired electric power plants
____c. Strip mining
____d. High voltage transmission lines and coal-fired power plants.
____e. High voltage transmission lines and strip mining.
____f. Coal-fired power plants and strip mining.
____g. High voltage transmission lines, coal-fired power plants, and strip mining.
____h. None of the above.

26. Would you be willing to accept a new industry into the area in which you live even if that industry might create or add to the pollution of the land, air or water? (check one)

( ) Yes ( ) No ( ) Undecided

26A. If yes: How much of an increase in pollution would you be willing to accept beyond the existing conditions of your area? (check one)

( ) Unlimited ( ) Very much ( ) Quite a bit ( ) A little
( ) Undecided

27. Would you be willing to accept a new industry into the area in which you live even if that industry might result in an increase in population? (check one)

( ) Yes ( ) No ( ) Undecided

27A. If yes: How much of an increase in population would you be willing to accept beyond the existing conditions of your area? (check one)

( ) Unlimited ( ) Very much ( ) Quite a bit ( ) A little
( ) Undecided

28. If additional coal-burning electric power plants are built at Colstrip, Montana, I would expect electric rates to: (check one)

( ) Decrease
( ) Stay about the same
( ) Increase
( ) I wouldn't be affected because I receive electricity from a company that is not involved with the Colstrip project.
( ) Undecided
( ) I don't have electricity.

29. National energy needs can best be met by: (check one)

( ) increasing strip mining in Montana
( ) increasing the number of electric generating plants in Montana
( ) individuals and families conserving energy
( ) industry and commercial institutions conserving energy
( ) developing alternative sources of energy such as the sun and wind
( ) other (specify) ______________________________

30. In general, and as a rule, who should pay the local economic costs of industrialization of coal resources such as expansion of law enforcement, public health, educational services, etc.? (check one)

( ) industry
( ) local government
( ) state government
( ) federal government
( ) the people who directly benefit from the energy produced
( ) all of the above
( ) none of the above (indicate who should pay in this case)____________

31. Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the resonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much? (check one)

( ) There should be no further development; what we have under way is enough.
( ) Further development should be confined to mining and exporting coal.

( ) Further development should be confined to mining and mine-mouth coal-burning electric power plants.
( ) Further development should not be restricted, but should be a direct response to what the rest of the nation says it wants.

CONFIDENTIAL

Section 3: Instructions: In this section we need some personal information about yourself. Place a check mark or write the appropriate response in the space provided. Please remember that this questionnaire is confidential and anonymous.

32. Sex: (Check One) ( ) Male ( ) Female

33. Age: (Check One)
( ) 15-24
( ) 25-34
( ) 35-44
( ) 45-54
( ) 55-64
( ) 65-74
( ) 75 +

34. Education: (Check One)

( ) Elementary school (8 years or less)
( ) Some High School
( ) High School Graduate
( ) Some College (Include vocational-technical schools)
( ) College Graduate
( ) Graduate or professional training

35. Occupation (be specific):

Self ______________________________

Spouse (if applicable) ______________________________

36. Are you a native-born Montanan? (Check One) ( ) Yes ( ) No

37. Length of residence in Montana: (Check One)

( ) Less than one year
( ) 1-5 years
( ) 6-10 years
( ) 11-15 years
( ) 16-25 years
( ) more than 25 years

38. Race and Ethnicity: (Check One)

( ) Caucasion
( ) American Indian
( ) Other (Specify) ____________________

39. Political Affiliation: (Check One)

( ) Democrat
( ) Republican
( ) Independent
( ) Other (Specify) ____________________

40. Estimated annual family income before taxes (Check One).

( ) Less than $2,999
( ) $3,000 - $4,999
( ) $5,000 - $6,999
( ) $7,000 - $9,999
( ) $10,000 - $14,999
( ) $15,000 - $24,999
( ) $25,000 +

41. County of Residence? ____________________

42. Place of residence by size: (Check One)

( ) City greater than 50,000 population
( ) City population from 10,000 - 49,999
( ) City population from 2,500 - 9,999
( ) City or town less than 2,499 population
( ) Rural--farm or ranch
( ) Suburban Lot
( ) Other (specify) ____________________

43. Is there a right-of-way for any of the following facilities located on your property, or have you sold right-of-way for any of these facilities? (Check all that apply)

( ) Railroad	( ) Yes
( ) Highway	
( ) Pipeline	( ) No
( ) Power line	

44. If you wish to receive a copy of the opinion poll results please write your name and address in the space provided or send a post card to the Energy Planning Division with your request.

45. Do you have any additional comments concerning the issues of coal development and electric utility construction in Montana? In the space below or on the back side of the questionnaire, please add any remarks you may wish to make.

H4 Revised Public Opinion Survey Results

This appendix contains tables which update the information contained in Section 11.2.2.2.D., which illustrated the results of a state-wide public opinion survey conducted by the Energy Planning Division. Tables in that section summarize the results of 778 questionnaires returned prior to the initiation of a mail follow-up during the week of September 9, 1974. The results presented in this appendix include the 160 additional questionnaires received after September 9, but prior to September 28, 1974, the cut-off date for accepting returned questionnaires. Of the 160 additional questionnaires returned, 86 were Form A (see Appendix H3), raising that form total to 509, and 74 were Form B, raising that form total to 429. The total of 938 questionnaires represents a return rate of 43.3%.

The attached tables express the survey results as raw percentages. The additional questionnaires do not alter the results illustrated in the main body of the impact statement. The trend of opinion holds firm. Changes in the percentage scores are indicated but the changes are small, on the order of 0.5%-2.0%. Where mean scores have been calculated, the additional questionnaires resulted in changes ranging from 0.01-0.1 point. Again, these are minor shifts in opinion and do not alter the previously indicated trends.

TABLE 1a

Montana Energy Survey

Sample Description

SEX

Male	Female	Not Specified
72.7%	24.5%	2.8%

N=938

AGE

15-24 years	7.9%	55-64 years	11.5%
25-34 years	27.7%	65-74 years	3.4%
35-44 years	19.6%	75 or more	1.4%
45-54 years	25.2%	not specified	3.3%

N=938

EDUCATION

3.9%	Elementary School (8 years or less)
5.4%	Some High School
17.9%	High School Graduate
26.4%	Some College
19.5%	College Graduate
24.5%	Graduate or Professional Training
2.2%	Not Specified

N=938

TABLE 1a

Montana Energy Survey

Sample Description

OCCUPATION

31.6%	Professional, Technical and Kindred Workers
9.8%	Business, Managers, and Administrators
9.2%	Clerical and Sales Workers
5.3%	Craftsmen and Foremen
17.2%	Operatives and Service Workers
6.1%	Homemakers
7.5%	Agriculture, Farm Owners, Managers, and Workers
4.7%	Retired
8.7%	Unemployed, Students, Occupation Not Specified

N=938

MONTANA NATIVE

yes	no	not specified
19.9%	77.2%	2.9%

N=938

LENGTH OF RESIDENCE IN MONTANA

1.4%	Less than one year
27.5%	One to five years
16.0%	Six to ten years
10.8%	Eleven to fifteen years
15.5%	Sixteen to twenty-five years
26.4%	More than twenty-five years
2.5%	Not specified

N=938

TABLE 1a

Montana Energy Survey

Sample Description

RACE

Caucasion	American Indian	Other	Not Specified
94.5%	1.2%	1.1%	3.3%

N=938

POLITICAL AFFILIATIONS

Democrat	Republican	Independent	Other	Not Specified
28.4%	23.9%	37.7%	5.3%	4.7%

N=938

ANNUAL FAMILY INCOME

2.7%	Less than $2,999
5.3%	$3,000 to $4,999
9.0%	$5,000 to $6,999
15.0%	$7,000 to $9,999
27.0%	$10,000 to $14,999
24.9%	$15,000 to $24,999
11.2%	$25,000 plus
4.9%	Not Specified

N=938

TABLE 1a

Montana Energy Survey

Sample Description

PLACE OF RESIDENCE

17.7%	City greater than 50,000 population
24.1%	City, population from 10,000 to 49,999
17.9%	City, population from 2,500 to 9,999
13.1%	City or town less than 2,499
16.5%	Rural--farm or ranch
4.7%	Suburban lot
2.3%	Other
3.6%	Not Specified

N=938

LOCATION OF RIGHT-OF-WAY ON PROPERTY

yes	no	not specified
14.0%	76.8%	9.2%

N=938

TYPE OF RIGHT-OF-WAY

1.9%	Railroad
5.2%	Highway
4.9%	Pipeline
14.6%	Power Line

N=938

TABLE A

Montana Energy Survey

STRIP MINING

Strip mining should not be prohibited in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13.9%	36.5%	13.9%	20.2%	14.5%

No Response 0.8% N=509

I favor the unrestricted strip mining of Montana coal.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
0.8%	3.3%	4.5%	24.2%	65.4%

No Response 1.8% N=509

Strip mining Montana's coal is acceptable if strong environmental safeguards are provided to protect the land, air, water and lifestyle of Montana residents.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
27.9%	45.4%	7.1%	11.0%	8.4%

No Response 0.2% N=509

The mining companies cannot be trusted to provide environmental safeguards unless compelled to do so by law.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
49.7%	34.6%	5.7%	6.7%	1.4%

No Response 2.0% N=509

I would prefer to live in an area without the presence of strip mining operations.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
49.4%	23.1%	14.9%	9.3%	2.7%

No Response 0.6% N=938

TABLE B

Montana Energy Survey

TRANSMISSION LINES

I favor the construction of high voltage electric transmission lines within Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.7%	28.1%	24.5%	18.0%	20.7%

No Response 1.0% N=938

I would prefer to live in an area without the presence of high voltage electric transmission lines.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
30.6%	29.2%	24.6%	10.9%	3.6%

No Response 1.1% N=938

I would have <u>no</u> objection to the presence of a high voltage electric transmission line on my property.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2.6%	16.9%	17.3%	24.2%	37.1%

No Response 2.0% N=509

Provided high voltage electric transmission lines are <u>not</u> located on my property, I have <u>no</u> objection to having them built elsewhere.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.2%	13.0%	25.9%	36.1%	21.2%

No Response 2.6% N=509

High voltage electric transmission lines should not be constructed in areas where power lines currently exist.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10.8%	47.9%	23.0%	12.4%	4.3%

No Response 1.6% N=509

TABLE C

Montana Energy Survey

TRANSMISSION LINES

High voltage electric transmission lines should be built in relatively uninhabited areas of the state.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
9.0%	35.5%	18.8%	24.1%	10.6%

No Response 2.0% N=509

High Voltage electric transmission lines should only be constructed if they are designed to specifically serve Montana residents.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13.8%	36.7%	17.3%	25.7%	4.3%

No Response 2.2% N=509

Power companies should pay an annual fee to property owners whose lands are crossed by electric transmission lines.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
26.1%	46.2%	16.5%	8.3%	2.0%

No Response 1.0% N=509

TABLE D

Montana Energy Survey

POWER PLANT

I favor the construction of coal burning electric generating power plants in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.1%	20.8%	17.7%	24.8%	28.5%

No Response 1.2% N=509

I would have no objection to living in an area where coal burning electric power plants are located.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.0%	17.0%	11.8%	24.9%	40.7%

No Response 0.9% N=938

Coal burning electric power plants and agriculture can co-exist side-by-side in the same area.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.1%	33.8%	24.8%	20.6%	13.2%

No Response 2.6% N=509

If coal burning electric power plants are to be built in Montana, it is best to locate the plants in areas already used for industrial purposes.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10.0%	41.5%	19.4%	23.6%	3.3%

No Response 2.2% N=509

Construction of coal burning electric power plants is acceptable if strong environmental safeguards are provided to protect the land, air, water, and lifestyle of Montana residents.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
21.8%	39.1%	9.0%	16.3%	12.4%

No Response 1.4% N=509

TABLE E

Montana Energy Survey

POWER PLANT

The consumers of electricity should bear the social and environmental costs associated with the construction and operation of coal burning electric power plants.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14.9%	34.0%	10.6%	25.5%	13.9%

No Response 1.0% N=509

If a power company wishes to construct a coal burning electric power plant, it should not be required to pay the additional cost of providing schools, sewers, roads, recreational facilities, etc. in the area

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2.0%	12.6%	10.0%	32.4%	40.9%

No Response 2.2% N=509

If a power company wishes to construct a coal burning power plant, it should be required to pre-pay the additional cost of providing schools, sewers, roads, recreational facilities,etc. in the area.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
32.0%	35.0%	16.3%	12.6%	2.6%

No Response 1.6% N=509

The taxes generated by the construction and operation of power plants and electric transmission lines will result in a lessening of the tax load paid by other Montana citizens.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.8%	22.8%	15.1%	36.7%	17.8%

No Response 1.8% N=938

TABLE F

Montana Energy Survey

POWER PLANT

Encouraging the construction and operation of power plants and electric transmission lines would be a wise step toward providing future generations of Montanans with job opportunities.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.9%	31.2%	16.7%	27.6%	15.0%

No Response 1.5%   N=938

I oppose the construction of coal burning electric power plants in Montana when the electricity is largely shipped to other states.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
44.5%	24.6%	7.9%	15.8%	6.1%

No Response 1.2% N=938

If Montana coal is needed for the generation of electricity, the coal should be transported to the areas where the electricity is needed.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
25.9%	35.8%	13.9%	17.9%	5.3%

No Response 1.2%   N=509

Coal burning electric power plants should be built in the areas where the elcectic power will be consumed.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24.0%	35.0%	16.5%	19.6%	3.5%

No Response 1.4%   N=509

Montana needs the electricity from the proposed coal burning electric generating plants to be located at Colstrip, Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.7%	25.5%	24.8%	27.9%	13.0%

No Response 2.2%   N=509

TABLE G

Montana Energy Survey

POWER PLANT

If additional coal burning electric power plants are built at Colstrip, Montana, I would expect electric rates to:

19.6% Decrease

32.9% Stay about the same

28.7% Increase

0.2% I don't have electricity

9.6% I wouldn't be affected because I receive electricity from a company that is not involved with the Colstrip project.

4.4% Undecided

No Response 4.7% N=429

If you were asked to select a location within Montana where the construction and operation of a coal burning electric power plant would do the most good and least harm, where would you locate such a plant?

TEN MOST FREQUENTLY LISTED COUNTIES	FIRST CHOICE	SECOND CHOICE	TOTAL
1. Rosebud	202	56	258
2. Yellowstone	51	40	91
3. Silver Bow	61	28	89
4. Cascade	22	38	60
5. Custer	17	24	41
6. Deer Lodge	17	19	36
7. Powder River	12	19	31
8. Lewis & Clark	13	12	25
9. Carter	12	11	23
10. Big Horn	2	17	19

TABLE H

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

In order to live in Montana, I am willing to pass by opportunities for potentially higher income that might be earned elsewhere.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
37.8%	36.2%	7.9%	12.4%	3.9%

No Response 1.7% N=938

I prefer to live in Montana as it currently is rather than risk possibly damaging the State by further industrialization.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
37.3%	25.9%	9.2%	20.0%	6.3%

No Response 1.3% N=938

The industrial development of Montana should be encouraged.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13.3%	29.2%	15.1%	24.1%	17.3%

No Response 1.0% N=938

One way of providing future generations of Montanans with job opportunities is to promote the industrialization of the state.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
12.0%	42.6%	13.4%	20.0%	10.6%

No Response 1.4% N=509

If new industry is to be built in Montana, it should be directed to areas of the state that are already industrialized.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
16.4%	33.6%	16.3%	26.9%	5.3%

No Response 1.5% N=938

TABLE I

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

The need for electricity will require injuring the beauty of an area by constructing and operating electric utilities.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14.1%	33.4%	12.2%	30.1%	9.6%

No Response 0.6% N=509

National energy needs can best be met by:

7.0% increasing strip mining in Montana
8.4% increasing the number of electric generating plants in Montana
4.6% individuals and families conserving energy
10.9% industry and commercial institutions conserving energy
42.2% developing alternative sources of energy such as the sun and wind
9.3% other
No Response 17.6% N=938

Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much?

24.6% There should be no further development; what we have under way is enough
32.0% Further development should be confined to mining and exporting coal.
21.3% Further development should be confined to mining and mine-mouth coal burning electric power plants.
11.9% Further development should not be restricted, but should be a direct response to what the rest of the nation says it wahts.
No Response 10.1% N=938

TABLE I

Montana Energy Survey

INDUSTRIAL DEVELOPMENT (cont)

In general, as a rule, who should pay the local economic costs of resources such as expansion of law enforcement, public health, educational services, etc.?

23.0% industry
4.1% local government
2.6% state government
2.6% federal government
21.1% the people who directly benefit from the energy produced
34.0% all of the above
1.8% none of the above
No Response 10.9% N=938

TABLE J

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

Would you be willing to accept a new industry into the area in which you live even if that industry might create or add to the pollution of the land, air or water?

Yes	No	Undecided
23.1%	66.0%	7.2%

No Response 3.7% N=429

If yes: How much of an increase in pollution would you be willing to accept beyond the existing conditions of your area?

Unlimited	Very Much	Quite a Bit	A Little	Undecided
2.0%	7.1%	18.2%	66.7%	6.1%

N=99

Would you be willing to accept a new industry into the area in which you live even if that industry might result in an increase in population?

Yes	No	Undecided
58.0%	31.2%	8.6%

No Response 2.1% N=429

If yes: How much of an increase in population would you be willing to accept beyond the existing conditions of your area?

Unlimited	Very Much	Quite a Bit	A Little	Undecided
7.3%	9.6%	32.9%	47.4%	2.8%

N=249

TABLE K

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

Again, using the 5 point scale rank the following list of industries according to your opinion as to their desirability to have located or expanded in Montana.

Less Desirable 1	2	3	4	More Desirable 5

N=	Mean Score	
402	2.81	Underground mining
407	3.71	Recreation and tourism
405	3.69	Light industry such as textiles and clothing, printing and publishing, etc.
398	1.98	Strip mining
410	3.45	Food processing such as slaughterhouses, flour mills, canneries, etc.
405	2.12	Heavy industry such as smelting, sawmills, oil refining, metal fabricating, etc.
405	2.75	Generation and transmission of electricity
404	3.76	Wholesale and retail trade
408	4.36	Agriculture
404	3.39	Transportation

Rank the following list of potential industrial facilities according to your opinion of their desirability within Montana.

Less Desirable 1	2	3	4	More Desirable 5

N=	Mean Score	
378	2.48	High voltage electric transmission lines.
381	2.15	Coal fired electric power plants
381	1.92	Strip mining
382	2.09	High voltage transmission lines and coal fired power plants.
380	1.91	High voltage transmission lines and strip mining.
379	1.85	Coal fired power plants and strip mining.
374	1.82	High voltage transmission lines, coal fired power plants, and strip mining.
173	3.59	None of the above

TABLE L

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

Below is a list of potentially adverse features which might be expected to accompany the construction and operation of strip mines, coal burning electric power plants, and high voltage electric transmission lines. Rank each of the items based on your opinion as to how adverse such an event would be should it occur.

Less Adverse				More Adverse
1	2	3	4	5

N=	Mean Score	
402	2.80	A potential increase in crime and other forms of deviant behavior.
404	3.37	A potential population increase
406	4.06	A potential increase in the pollution of land, air, and water.
395	3.18	A potential for cost of living increases.
405	3.61	A potential for the loss of water from agricultural to industrial use.
408	3.71	A potential increase in health hazards to man, animals,and plants.
403	3.30	A potential loss of or damage to existing recreational facilities.
397	2.18	A potential breakdown of friendship and family ties.
400	3.09	A potential for increases in taxation to owners of residential, commercial, and agricultural property.
401	3.46	A potential loss of agricultural land to industrial use.
401	3.45	A potential overcrowding of educational facilities.
393	2.35	A potential for damage to existing transportation facilities.
402	3.25	A potential overcrowding of housing facilities.
385	2.28	A potential for damage to the established business community.

TABLE M

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

Below is a list of potentially beneficial features which might be expected to accompany the construction and operation of strip mines, coal burning electric power plants, and high voltage electric transmission lines. Rank each of the items based on your opinion as to how beneficial such an event would be should it occur.

Less Beneficial 1	2	3	4	More Beneficial 5

N=	Mean Score	
399	2.25	A potential population increase.
404	2.99	A potential improvement in educational facilities.
404	2.58	A potential improvement in recreational facilities.
401	2.62	A potential opportunity to meet new people.
400	3.02	A potential for improvement in shopping and professional services.
408	3.59	A potential increase in job opportunities.
407	3.16	A potential increase in tax revenues.
399	2.62	A potential for improvement in social and cultural facilities.
405	2.55	A potential improvement in housing facilities.
401	2.66	A potential improvement in transportation facilities.
402	2.82	A potential improvement in opportunities for capital investment.
406	3.31	A potential contribution to industrial growth and energy self-sufficiency for the United States.
404	2.82	A potential to attract more industry to the area.
400	3.15	A potential for broadening the economic base of Montana.

TABLE N

Montana Energy Survey

INDUSTRIAL DEVELOPMENT

On the whole, do the potential beneficial features of coal development and the construction and operation of electric utilities equal the potential adverse features?

Yes	No	Undecided
27.7%	53.6%	12.6%

No response 6.1% N=429

Do the potential beneficial features outweigh the potential adverse features?

Yes	No
12.8%	87.2%

N=235

If Yes:
How much do the potential beneficial features outweigh the potential adverse features?

46.7% Very much
36.7% Quite a bit
13.3% A little
3.3% Undecided

N=30

Do the potential adverse features outweigh the potential beneficial features?

Yes	No
89.3%	10.7%

N=225

If Yes:
How much do the potential adverse features outweigh the potential beneficial features?

58.1% Very much
35.3% Quite a bit
4.2% A Little
2.4% Undecided

N=167

TABLE O

Montana Energy Survey

PUBLIC INFORMATION

I am very interested in the issues of coal development and the construction of electric utilities in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
36.6%	39.7%	13.1%	5.1%	4.8%

No Response 0.7% N=938

I consider myself well informed about the issues of coal development and electric utility construction in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
12.4%	40.7%	21.2%	22.0%	3.3%

No Response 0.4% N=938

How many news articles, broadcasts, documentaries, or programs have you seen, heard, or read in the past six months dealing with Montana coal development and electric utility construction?

None	1-5	6-10	11-15	16 or more
3.5%	27.1%	27.2%	13.8%	26.7%

No Response 1.8% N=938

Most people in Montana are well informed about the issues of coal development and electric utility construction.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
0.8%	9.8%	14.7%	55.6%	18.1%

No Response 1.0% N=509

TABLE O

Montana Energy Survey

PUBLIC INFORMATION (cont)

Below is a list of possible sources of information. Using the 5 point scale rank these sources according to how frequently you use them to receive information concerning coal development and electric utility construction in Montana.

Seldom 1	2	3	4	Often 5

N=	Mean Score	
863	2.93	Conversationwith other people
849	2.66	Magazines
854	2.76	Radio
816	1.78	Public Meetings
868	3.27	Television
876	3.76	Newspapers

TABLE P

Montana Energy Survey

PUBLIC INFORMATION

Not much information concerning coal development and the construction of electric utilities in Montana is being made available to the general public.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
15.9%	41.7%	14.5%	23.1%	3.9%

No Response 0.9% N=938

Rank the items below in terms of how much (not accuracy) information you believe these organizations provide the general public concerning the issues of coal development and electric utility construction.

Less Information				More Information
1	2	3	4	5

N=	Mean Score	
863	2.22	Federal Government Agencies
875	2.74	State Government Agencies
873	3.06	Power Companies
870	3.66	Environmental Groups
833	1.76	Labor Unions
856	2.62	Citizens Groups
856	2.39	Mining Companies
842	1.96	Local Government Agencies
869	3.34	The News Media (excluding news releases from other organizations)

TABLE Q

Montana Energy Survey

PUBLIC INFORMATION

By a large, the information the Montana public receives concerning the issues of coal development and electric utility construction within the state is accurate.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.4%	15.3%	36.0%	36.0%	9.6%

No Response 1.8% N=509

Again, using the 5 point scale rank the organizations based on your opinion of the accuracy of the information they make available to the public.

Less Accurate 1	2	3	4	More Accurate 5

N=	Mean Score	
835	2.93	Citizens Groups
806	2.11	Labor Unions
848	2.76	Federal Government Agencies
828	2.67	Local Government Agencies
847	3.05	The News Media (excluding news releases from other organizations)
833	1.98	Mining Companies
850	2.08	Power Companies
851	3.05	Environmental Groups
846	2.90	State Government Agencies

Is there any type of organization which is providing information concerning coal development and electric utility construction in Montana that you distrust?

	Yes	No	Undecided
	61.4%	11.9%	20.9%
No Response 5.8%	N=938		

TABLE Q

Montana Energy Survey

PUBLIC INFORMATION (cont)

If yes: What type of organization do you distrust?

1.	Citizens Groups	3.4%
2.	Labor Unions	1.4%
3.	Federal Government Agencies	2.4%
4.	Local Government Agencies	0.5%
5.	The News Media	2.7%
6.	Mining Companies	17.5%
7.	Power Companies	50.6%
8.	Environmental Groups	14.3%
9.	State Government Agencies	2.1%

N=553